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ABSTRACT

This Unified Sciences and Mathematics for Elementary Schools (USMES) unit challenges students to improve traffic flow at a problem location. The challenge is general enough to apply to many problem-solving situations in mathematics, science, social science, and language arts at any elementary school level (grades 1-8). The Teacher Resource Book for the unit is divided into five sections. Section I describes the USMES approach to student-initiated investigations of real problems, including a discussion of the nature of USMES "challenges." Section II provides an overview of possible student activities with comments on prerequisite skills, instructional strategies, suggestions when using the unit with primary grades, a flow chart illustrating how investigations evolve from students' discussions of traffic flow problems, and a hypothetical account of intermediate-level class activities. Section III provides documented events of actual grade 5 class activities. Section IV includes lists of "How To" cards and background papers, bibliography of non-USMES materials, and a glossary. Section V consists of charts identifying skills, concepts, processes, and areas of study learned as students become involved with traffic flow investigations. (JN)

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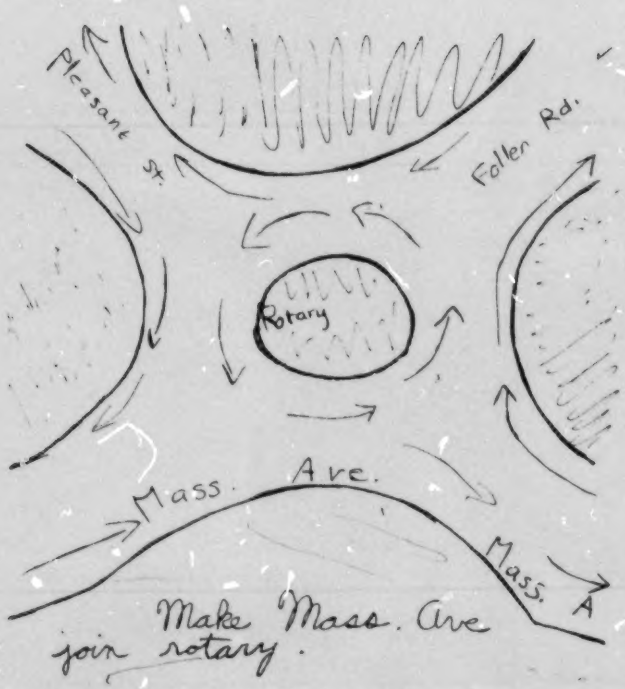
UNIFIED SCIENCES AND MATHEMATICS FOR ELEMENTARY SCHOOLS:
Mathematics and the Natural, Social, and Communications Sciences in Real Problem Solving.

Traffic Flow

Fourth Edition



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CHALLENGE: RECOMMEND AND TRY TO HAVE A CHANGE ACCEPTED SO THAT THE FLOW OF TRAFFIC WILL BE IMPROVED AT A NEARBY PROBLEM LOCATION.

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Preface

The USMES Project

Unified Sciences and Mathematics for Elementary Schools: Mathematics and the Natural, Social, and Communications Sciences in Real Problem Solving (USMES) was formed in response to the recommendations of the 1967 Cambridge Conference on the Correlation of Science and Mathematics in the Schools.* Since its inception in 1970, USMES has been funded by the National Science Foundation to develop and carry out field trials of interdisciplinary units centered on long-range investigations of real and practical problems (or "challenges") taken from the local school/community environment. School planners can use these units to design a flexible curriculum for grades one through eight in which real problem solving plays an important role.

Development and field trials were carried out by teachers and students in the classroom with the assistance of university specialists at workshops and at occasional other meetings. The work was coordinated by a staff at the Education Development Center in Newton, Massachusetts. In addition, the staff at EDC coordinated implementation programs involving schools, districts, and colleges that are carrying out local USMES implementation programs for teachers and schools in their area.

Trial editions of the following units are currently available:

- Advertising
- Bicycle Transportation
- Classroom Design
- Classroom Management
- Consumer Research
- Describing People
- Designing for Human Proportions
- #Design Lab Design
- #Eating in School
- Getting There
- Growing Plants
- Manufacturing
- Mass Communications
- Nature Trails
- Orientation
- Pedestrian Crossings
- Play Area Design and Use
- Protecting Property
- #School Rules
- School Supplies
- School Zoo
- Soft Drink Design
- Traffic Flow
- #Using Free Time
- Ways to Learn/Teach
- Weather Predictions

*See *Goals for the Correlation of Elementary Science and Mathematics*, Houghton Mifflin Co., Boston, 1969.

#Available fall 1976.

USMES Resources

In responding to a long-range challenge, the students and teachers often have need of a wide range of resources. In fact, all of the people and materials in the school and community are important resources for USMES activities. USMES provides resources in addition to these. One resource for students is the Design Lab or its classroom equivalent: using the tools and supplies available, children can follow through on their ideas by constructing measuring tools, testing apparatus, models, etc. Another resource for students is the *"How To" Cards*. Each set of cards gives information about a specific problem; the students use a set only when they want help on that particular problem.

Several types of resources are available for teachers: the *USMES Guide*, a *Teacher Resource Book* for each challenge, *Background Papers*, a *Design Lab Manual*, and a *Curriculum Correlation Guide*. A complete set of all these written materials comprise what is called the USMES library. This library, which should be available in each school using USMES units, contains the following:

1. *The USMES Guide*

   The USMES Guide is a compilation of materials that may be used for long-range planning of a curriculum that incorporates the USMES program. In addition to basic information about the project, the challenges, and related materials, it contains charts assessing the strengths of the various challenges in terms of their possible subject area content.

2. *Teacher Resource Books* (one for each challenge)

   Each book contains a description of the USMES approach to real problem-solving activities, general information about the particular unit, edited logs of class activities, other written materials relevant to the unit, and charts that indicate the basic skills, processes, and areas of study that may be learned and utilized as students become engaged in certain possible activities.

3. *Design Lab Manual*

   This contains sections on the style of Design Lab activities, safety considerations, and an inventory

of tools and supplies. Because many "hands-on" activities may take place in the classroom, the Design Lab Manual should be made available to each USMES teacher.

4. *"How To" Cards*

   These short sets of cards provide information to students about specific problems that may arise during USMES units. Particular computation, graphing, and construction problems are discussed. A complete list of the "How To" Cards can be found in the USMES Guide.

5. *Background Papers*

   These papers are written to provide information for the teachers on technical problems that might arise as students carry on various investigations. A complete list of the Background Papers can be found in the USMES Guide.

6. *Curriculum Correlation Guide*

   This volume is intended to coordinate other curriculum materials with the Teacher Resource Books and to provide the teacher with the means to integrate USMES easily into other school activities and lessons.

The preceding materials are described in brief in the USMES brochure, which can be used by teachers and administrators to disseminate information about the program to the local community. A variety of other dissemination and implementation materials are also available for individuals and groups involved in local implementation programs. They include *Preparing People for USMES: An Implementation Resource Book*, the USMES slide/tape show, the Design Lab slide/tape show, the Design Lab brochure, the USMES newsletter, videotapes of classroom activities, a general report on evaluation results, a map showing the locations of schools conducting local implementation of USMES, a list of experienced USMES teachers and university consultants, and newspaper and magazine articles.

Acknowledgments

Besides the contributors listed at the beginning of the book, we are deeply indebted to the many elementary school

children whose investigations of the challenge form the basis for this book. Without their efforts this book would not have been possible. Many thanks to the Planning Committee for their years of service and advice. Many thanks also to other members of the USMES staff for their suggestions and advice and for their help in staffing and organizing the development workshops. Special thanks also go to Christopher Hale for his efforts as Project Manager during the development of this book.

* * *

Because Tri-Wall was the only readily available brand of three-layered cardboard at the time the project began, USMES has used it at workshops and in schools; consequently, references to Tri-Wall can be found throughout the Teacher Resource Books. The addresses of companies that supply three-layered cardboard can be found in the Design Lab Manual.

Introduction

Using the Teacher Resource Book

When teachers try a new curriculum for the first time, they need to understand the philosophy behind the curriculum. The USMES approach to student-initiated investigations of real problems is outlined in section A of this Teacher Resource Book.

Section B starts with a brief overview of possible student activities arising from the challenge; comments on prerequisite skills are included. Following that is a discussion of the classroom strategy for USMES real problem-solving activities, including introduction of the challenge, student activity, resources, and Design Lab use. Subsequent pages include a description of the use of the unit in primary grades, a flow chart and a composite log that indicate the range of possible student work, and a list of questions that the teacher may find useful for focusing the students' activities on the challenge.

Because students initiate all the activities in response to the challenge and because the work of one class may differ from that undertaken by other classes, teachers familiar with USMES need to read only sections A and B before introducing the challenge to students.

Section C of this book is the documentation section. These edited teachers' logs show the variety of ways in which students in different classes have worked at finding a solution to the challenge.

Section D contains a list of the titles of relevant sets of "How To" Cards and brief descriptions of the Background Papers pertaining to the unit. Also included in section D is a glossary of the terms used in the Teacher Resource Book and an annotated bibliography.

Section E contains charts that indicate the comparative strengths of the unit in terms of real problem solving, mathematics, science, social science, and language arts. It also contains a list of explicit examples of real problem solving and other subject area skills, processes, and areas of study learned and utilized in the unit. These charts and lists are based on documentation of activities that have taken place in USMES classes. Knowing ahead of time which basic skills and processes are likely to be utilized, teachers can postpone teaching that part of their regular program until later in the year. At that time students can study them in the usual way if they have not already learned them as part of their USMES activities.

A. Real Problem Solving and USMES

*If life were of such a constant nature that there were only a few chores to do and they were done over and over in exactly the same way, the case for knowing how to solve problems would not be so compelling. All one would have to do would be to learn how to do the few jobs at the outset. From then on he could rely on memory and habit. Fortunately--or unfortunately depending upon one's point of view--life is not simple and unchanging. Rather it is changing so rapidly that about all we can predict is that things will be different in the future. In such a world the ability to adjust and to solve one's problems is of paramount importance.**

Real Problem Solving

USMES is based on the beliefs that real problem solving is an important skill to be learned and that many math, science, social science, and language arts skills may be learned more quickly and easily within the context of student investigations of real problems. Real problem solving, as exemplified by USMES, implies a style of education which involves students in investigating and solving real problems. It provides the bridge between the abstractions of the school curriculum and the world of the student. Each USMES unit presents a problem in the form of a challenge that is interesting to children because it is both real and practical. The problem is real in several respects: (1) the problem applies to some aspect of student life in the school or community, (2) a solution is needed and not presently known, at least for the particular case in question, (3) the students must consider the entire situation with all the accompanying variables and complexities, and (4) the problem is such that the work done by the students can lead to some improvement in the situation. This expectation of useful accomplishment provides the motivation for children to carry out the comprehensive investigations needed to find some solution to the challenge.

The level at which the children approach the problems, the investigations that they carry out, and the solutions

*Kenneth B. Henderson and Robert E. Pingry, "Problem-Solving in Mathematics," in *The Learning of Mathematics: Its Theory and Practice*, Twenty-first Yearbook of the National Council of Teachers of Mathematics (Washington, D.C.: The Council, 1953), p. 233.

that they devise may vary according to the age and ability of the children. However, real problem solving involves them, at some level, in all aspects of the problem-solving process: definition of the problem; determination of the important factors in the problem; observation; measurement; collection of data; analysis of the data using graphs, charts, statistics, or whatever means the students can find; discussion; formulation and trial of suggested solutions; clarification of values; decision making; and communications of findings to others. In addition, students become more inquisitive, more cooperative in working with others, more critical in their thinking, more self-reliant, and more interested in helping to improve social conditions.

The USMES Approach

To learn the process of real problem solving, the students must encounter, formulate, and find some solution to complete and realistic problems. The students themselves, not the teacher, must analyze the problem, choose the variables that should be investigated, search out the facts, and judge the correctness of their hypotheses and conclusions. In real problem-solving activities, the teacher acts as a coordinator and collaborator, not an authoritative answer-giver.

The problem is first reworded by students in specific terms that apply to their school or community, and the various aspects of the problem are discussed by the class. The students then suggest approaches to the problem and set priorities for the investigations they plan to carry out. A typical USMES class consists of several groups working on different aspects of the problem. As the groups report periodically to the class on their progress, new directions are identified and new task forces are formed as needed. Thus, work on an USMES challenge provides students with a "discovery-learning" or "action-oriented" experience.

Real problem solving does not rely solely on the discovery-learning concept. In the real world people have access to certain facts and techniques when they recognize the need for them. The same should be true in the classroom. When the students find that certain facts and skills are necessary for continuing their investigation, they learn willingly and quickly in a more directed way to acquire these facts and skills. Consequently, the students should have available different resources that they may use as they recognize the need for them, but they should still be left with a wide scope to explore their own ideas and methods.

Certain information on specific skills is provided by the sets of USMES "How To" Cards. The students are referred only to the set for which they have clearly identified a need and only when they are unable to proceed on their own. Each "How To" Cards title clearly indicates the skill involved--"How to Use a Stopwatch," "How to Make a Bar Graph Picture of Your Data," etc. (A complete list of the "How To" Cards can be found in Chapter IX of the USMES Guide.)

Another resource provided by USMES is the Design Lab or its classroom equivalent. The Design Lab provides a central location for tools and materials where devices may be constructed and tested without appreciably disrupting other classroom activities. Ideally, it is a separate room with space for all necessary supplies and equipment and work space for the children. However, it may be as small as a corner of the classroom and may contain only a few tools and supplies. Since the benefits of real problem solving can be obtained by the students only if they have a means to follow up their ideas, the availability of a Design Lab can be a very important asset.

Optimally, the operation of the school's Design Lab should be such as to make it available to the students whenever they need it. It should be as free as possible from set scheduling or programming. The students use the Design Lab to try out their own ideas and/or to design, construct, test, and improve many devices initiated by their responses to the USMES challenges. While this optimum operation of the Design Lab may not always be possible due to various limitations, "hands-on" activities may take place in the classroom even though a Design Lab may not be available. (A detailed discussion of the Design Lab can be found in Chapter VI of the USMES Guide, while a complete list of "How To" Cards covering such Design Lab skills as sawing, gluing, nailing, soldering, is contained in Chapter IX.)

Work on all USMES challenges is not only sufficiently complex to require the collaboration of the whole class but also diverse enough to enable each student to contribute according to his/her interest and ability. However, it should be noted that if fewer than ten to twelve students from the class are carrying out the investigation of a unit challenge, the extent of their discovery and learning can be expected to be less than if more members of the class are involved. While it is possible for a class to work on two related units at the same time, in many classes the students progress better with just one.

The amount of time spent each week working on an USMES challenge is crucial to a successful resolution of the

problem. Each challenge is designed so that the various investigations will take from thirty to forty-five hours, depending on the age of the children, before some solution to the problem is found and some action is taken on the results of the investigations. Unless sessions are held at least two or three times a week, it is difficult for the children to maintain their interest and momentum and to become involved intensively with the challenge. The length of each session depends upon the age level of the children and the nature of the challenge. For example, children in the primary grades may proceed better by working on the challenge more frequently for shorter periods of time, perhaps fifteen to twenty minutes, while older children may proceed better by working less frequently for much longer periods of time.

Student interest and the overall accomplishments of the class in finding and implementing solutions to the challenge indicate when the class's general participation in unit activities should end. (Premature discontinuance of work on a specific challenge is often due more to waning interest on the part of the teacher than to that of the students.) However, some students may continue work on a voluntary basis on one problem, while the others begin to identify possible approaches to another USMES challenge.

Importance of the Challenge

Although individual (or group) discovery and student initiation of investigations is the process in USMES units, this does not imply the constant encouragement of random activity. Random activity has an important place in children's learning, and opportunities for it should be made available at various times. During USMES activities, however, it is believed that children learn to solve real problems only when their efforts are focused on finding some solution to the real and practical problem presented in the USMES challenge. It has been found that students are motivated to overcome many difficulties and frustrations in their efforts to achieve the goal of effecting some change or at least of providing some useful information to others. Because the children's commitment to finding a solution to the challenge is one of the keys to successful USMES work, it is extremely important that the challenge be introduced so that it is accepted by the class as an important problem to which they are willing to devote a considerable amount of time.

The challenge not only motivates the children by stating the problem but also provides them with a criterion for judging their results. This criterion--if it works, it's right (or if it helps us find an answer to our problem, it's

a good thing to do)--gives the children's ideas and results a meaning within the context of their goal. Many teachers have found this concept to be a valuable strategy that not only allows the teacher to respond positively to all of the children's ideas but also helps the children themselves to judge the value of their efforts.

Role of the Teacher

With all of the above in mind, it can be said that the teacher's responsibility in the USMES strategy for open classroom activities is as follows:

1. Introduce the challenge in a meaningful way that not only allows the children to relate it to their particular situation but also opens up various avenues of approach.

2. Act as a coordinator and collaborator. Assist, not direct, individuals or groups of students as they investigate different aspects of the problem.

3. Hold USMES sessions at least two or three times a week so that the children have a chance to become involved in the challenge and carry out comprehensive investigations.

4. Provide the tools and supplies necessary for initial hands-on work in the classroom or make arrangements for the children to work in the Design Lab.

5. Be patient in letting the children make their own mistakes and find their own way. Offer assistance or point out sources of help for specific information (such as the "How To" Cards) only when the children become frustrated in their approach to the problem. Conduct skill sessions as necessary.

6. Provide frequent opportunities for group reports and student exchanges of ideas in class discussions. In most cases, students will, by their own critical examination of the procedures they have used, improve or set new directions in their investigations.

7. If necessary, ask appropriate questions to stimulate the students' thinking so that they will make more extensive and comprehensive investigations or analyses of their data.

8. Make sure that a sufficient number of students (usually ten to twelve) are working on the challenge so that activities do not become fragmented or stall.

Student success in USMES unit activities is indicated by the progress they make in finding some solution to the challenge, not by following a particular line of investigation nor by obtaining specified results. The teacher's role in the USMES strategy is to provide a classroom atmosphere in which all students can, in their own way, search out some solution to the challenge.

USMES in the Total School Program

Today many leading educators feel that real problem solving (under different names) is an important skill to be learned. In this mode of learning particular emphasis is placed on developing skills to deal with real problems rather than the skills needed to obtain "correct" answers to contrived problems. Because of this and because of the interdisciplinary nature of both the problems and the resultant investigations, USMES is ideal for use as an important part of the elementary school program. Much of the time normally spent in the class on the traditional approaches to math, science, social science, and language arts skills can be safely assigned to USMES activities. In fact, as much as one-fourth to one-third of the total school program might be allotted to work on USMES challenges. Teachers who have worked with USMES for several years have each succeeding year successfully assigned to USMES activities the learning of a greater number of traditional skills. In addition, reports have indicated that students retain for a long time the skills and concepts learned and practiced during USMES activities. Therefore, the time normally spent in reinforcing required skills can be greatly reduced if these skills are learned and practiced in the context of real problem solving.

Because real problem-solving activities cannot possibly cover all the skills and concepts in the major subject areas, other curricula as well as other learning modes (such as "lecture method," "individual study topics," or programmed instruction) need to be used in conjunction with USMES in an optimal education program. However, the other

instruction will be enhanced by the skills, motivation, and understanding provided by real problem solving, and, in some cases, work on an USMES challenge provides the context within which the skills and concepts of the major subject areas find application.

In order for real problem solving taught by USMES to have an optimal value in the school program, class time should be apportioned with reason and forethought, and the sequence of challenges investigated by students during their years in elementary school should involve them in a variety of skills and processes. Because all activities are initiated by students in response to the challenge, it is impossible to state unequivocally which activities will take place. However, it is possible to use the documentation of activities that have taken place in USMES trial classes to schedule instruction on the specific skills and processes required by the school system. Teachers can postpone the traditional way of teaching the skills that might come up in work on an USMES challenge until later in the year. At that time students can learn the required skills in the usual way if they have not already learned them during their USMES activities.

These basic skills, processes, and areas of study are listed in charts and lists contained in each Teacher Resource Book. A teacher can use these charts to decide on an overall allocation of class time between USMES and traditional learning in the major subject disciplines. Examples of individual skills and processes are also given so that the teacher can see beforehand which skills a student may encounter during the course of his investigations. These charts and lists may be found in section E.

Ways In Which USMES Differs From Other Curricula

As the foregoing indicates, USMES differs significantly from other curricula. Real problem solving develops the problem-solving ability of students and does it in a way (learning-by-doing) that leads to a full understanding of the process. Because of the following differences, some teacher preparation is necessary. Some teachers may have been introduced by other projects to several of the following new developments in education, but few teachers have integrated all of them into the new style of teaching and learning that real problem solving involves.

1. New Area of Learning--Real problem solving is a new area of learning, not just a new approach or a new content within an already-defined subject area. Although many subject-matter curricula

include something called problem solving, much of this problem solving involves contrived problems or fragments of a whole situation and does not require the cognitive skills needed for the investigation of real and practical problems. Learning the cognitive strategy required for real problem solving is different from other kinds of learning.

3. Interdisciplinary Education--Real problem solving integrates the disciplines in a natural way; there is no need to impose a multi-disciplinary structure. Solving real and practical problems requires the application of skills, concepts, and processes from many disciplines. The number and range of disciplines are unrestricted and the importance of each is demonstrated in working toward the solution of practical problems.

3. Student Planning--To learn the process of problem solving, the students themselves, not the teacher, must analyze the problem, choose the variables that should be investigated, search out the facts, and judge the correctness of the hypotheses and conclusions. In real problem-solving activities the teacher acts as a coordinator and collaborator, not as an authoritative source of answers.

4. Learning-by-Doing--Learning-by-doing, or discovery learning as it is sometimes called, comes about naturally in real problem solving since the problems tackled by each class have unique aspects; for example, different lunchrooms or pedestrian crossings have different problems associated with them and, consequently, unique solutions. The challenge, as defined in each situation, provides the focus for the children's hands-on learning experiences, such as collecting real data; constructing measuring instruments, scale models, test equipment, etc.; trying their suggested improvements; and (in some units) preparing reports and presentations of their findings for the proper authorities.

5. Learning Skills and Concepts as Needed--Skills and concepts are learned in real problem solving

as the need for them arises in the context of the work being done, rather than having a situation imposed by the teacher or the textbook being used. Teachers may direct this learning when the need for it arises, or students may search out information themselves from resources provided.

6. Group Work--Progress toward a solution to a real problem usually requires the efforts of groups of students, not just individual students working alone. Although some work may be done individually, the total group effort provides good opportunities for division of labor and exchange of ideas among the groups and individuals. The grouping is flexible and changes in order to meet the needs of the different stages of investigation.

7. Student Choice--Real problem solving offers classes the opportunity to work on problems that are real to them, not just to the adults who prepare the curriculum. In addition, students may choose to investigate particular aspects of the problem according to their interest. The variety of activities ensuing from the challenge allows each student to make some contribution towards the solution of the problem according to his or her ability and to learn specific skills at a time when he or she is ready for that particular intellectual structure.

B. General Papers on Traffic Flow

1. OVERVIEW OF ACTIVITIES

Challenge:

Recommend and try to have a change accepted so that the flow of traffic will be improved at a nearby problem location.

Possible Class Challenges:

How can the flow of traffic around the _____ traffic circle be improved so that children may cross the street safely and more quickly.

Investigate ways to change traffic patterns so that school buses could go faster along _____ Avenue. Try to have your recommendation accepted.

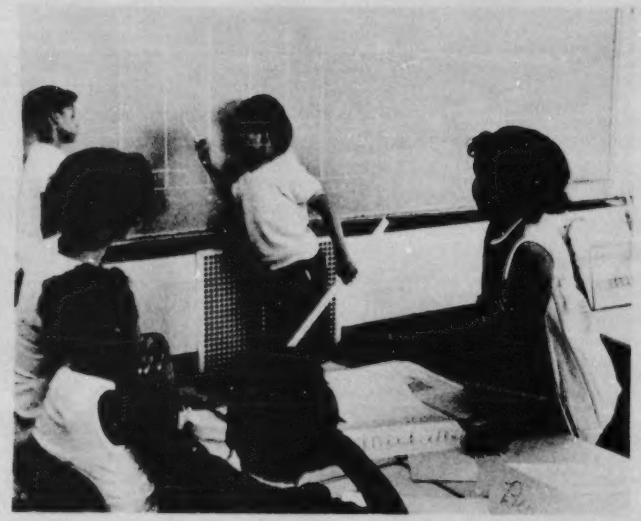
Make _____ Street a safer street to ride bicycles along.

Although children do not drive automobiles themselves, they are often endangered or inconvenienced by rush-hour traffic jams, speeding cars, and long waiting periods on street corners. Frequently, problems in crossing a street at an intersection may be solved during work on a Pedestrian Crossings challenge as children recommend the installation of stop signs or traffic signals or request that "WALK" lights be left on for longer periods of time. In many cases, children working on a Pedestrian Crossings problem will find that the best solution is to change the flow of automobile traffic at a dangerous intersection, leading to work on a Traffic Flow challenge.

In other cases a Traffic Flow problem will arise when the class finds that fast-moving cars endanger children riding bicycles or playing near or along a particular street. Sometimes class discussions of traffic jams or accidents at particular intersections or of problems children encounter while walking or riding the bus to school may lead to work on a Traffic Flow challenge (e.g., "What can we do to help cars move more quickly through the intersection of X and Y streets?"). Children might conduct a survey or study of traffic problems in the area before focusing on a challenge which concerns a particular problem location.

Once a target location has been chosen, the children hold class discussions to decide what things they need to know about the traffic patterns of the particular street or intersection. They identify some of the things that they feel can be improved at the problem location, such as speeds of automobiles or amount of time cars take to get through the intersection.

Working in groups, children may take photographs or movies of the area to document heavy traffic flow, "bottlenecks" that create traffic jams, or hazards to pedestrians and cyclists. They may interview local residents, store-owners, city officials, or other students to collect additional evidence of the problem and ideas for possible solutions. Other students collect quantitative data on the traffic problem. They may record arrival times of cars at the intersection or time cars passing between two points to determine speed. Other important data may be obtained from counting cars passing a particular point or stretch of roadway. This informa-



tion may be used to calculate traffic volume at the problem location. Classroom trial of traffic flow (children acting as cars) is beneficial as a means of testing data collection methods.

Once children have collected data through survey or measurement activities, they may make graphs to help in analyzing their information. Histograms of car speeds, bar graphs comparing traffic flow at different locations (or the same location at different times of day), and conversion graphs to help change car speeds from feet per second to miles per hour will be particularly useful to students working on a Traffic Flow problem.

Students may use the information obtained from graphs and data analysis for helping them decide on a particular solution to recommend to authorities. Older students may design simulation experiments, using data already collected, to try out some of their ideas. Possible solutions to various traffic problems include: rerouting traffic by means of one-way streets; imposing parking restrictions; constructing overpasses, underpasses, or access roads to highways; changing speed limits; increasing local bus services; or promoting car pools for commuters.

If the solution might involve a new road design, students may construct scale models in the Design Lab or draw scale maps to compare alternative designs.

In addition, they may want to obtain data on amount of curvature or length of acceleration and deceleration lanes. Other types of information they may need include data on sight distances or car braking distances.

Students may also research local traffic regulations and enforcement procedures or investigate accident statistics or spot maps. They might conduct cost analyses of their alternative solutions to find out which are the least expensive. If their solution involves a rerouting of traffic or construction of a roadway, they will find it helpful to obtain land use plans for the area to compare their suggestions with officially proposed changes.

Before promoting their solutions, the children will need to consolidate their work, arrive at a final set of recommendations, and prepare their presentation to the authorities--local or state traffic officials. If their solutions are accepted and implemented soon after presentation, children might conduct follow-up studies to determine the effectiveness of the changes. Other proposals may lead to additional activities on the part of the class, such as advertising campaigns at local industries or offices to pro-

mote establishment of car pools that would decrease traffic volume at rush hour. The children's continued interest in the problem may also lead to a study of transportation planning or to promotion of alternative transportation methods in the city or region. Techniques acquired in Traffic Flow investigations may also be applied to the Bicycle Transportation or Pedestrian Crossings challenges.

Although many of these activities may require skills and concepts new to the children, there is no need for preliminary work on these skills and concepts because the children can learn them when the need arises. In fact, children learn more quickly and easily when they see a need to learn. Consider counting: whereas children usually learn to count by rote, they can, through USMES, gain a better understanding of counting by learning or practicing it within real contexts. In working on Traffic Flow children also learn and practice graphing, measuring, working with decimals, and dividing. Although dividing seems necessary to compare fractions or ratios, primary children can make comparisons graphically; sets of data can also be compared graphically or by subtracting medians (half-way values). Furthermore, instead of using division to make scale drawings or models, younger children can convert their measurements to spaces on graph paper. Division may be introduced at the proper grade level during calculation of percentages or averages.

2. CLASSROOM STRATEGY FOR TRAFFIC FLOW

The Traffic Flow unit revolves around a challenge--a statement that says, "Solve this problem." Its success or failure depends largely on (1) the relevance of the problem for the students, and (2) the process by which they define and accept the challenge. If the children see the problem as a real one, they will be committed to finding a solution; they will have a focus and purpose for their activities. If the students do not think the problem affects them, their attempts at finding solutions are likely to be disjointed and cursory.

The challenge as stated in the Traffic Flow Resource Book is general enough to apply to many situations. Students in different classes define and reword the challenge to fit their particular situation and thus arrive at a specific class challenge. "Recommend and try to have a change accepted so that the flow of traffic will be improved at a

nearby problem location" has been restated by some classes in terms of a specific street with heavy traffic that causes traffic jams.

The Process of Introducing the Challenge

Given that a Traffic Flow problem exists, how can a teacher, without being directive, help the students identify the challenge that they will work on as a group? There is no set method because of the variations among teachers, classes, and schools. However, USMES teachers have found that certain techniques are helpful in introducing the Traffic Flow challenge.

One technique is to turn a spontaneous discussion of a recent event relating to a traffic problem toward a Traffic Flow challenge. For example, the teacher might focus a discussion of an automobile accident along a busy road on the challenge by asking the class how the accident could have been prevented.

A fifth-grade class in Arlington, Massachusetts, began the Traffic Flow unit through a discussion of traffic problems in the immediate vicinity of the school. Class attention focused on nearby Route 2 where a child had been killed the year before. Students related their personal reactions to the incident and possible actions which could be taken to make the road safer for the children who had to cross it.

A discussion of personal experiences with traffic jams or slow-moving traffic might be turned toward suggestions for improvements at intersections or along roadways that are frequently jammed.

A fifth-grade class in Watertown, Massachusetts, became involved in Traffic Flow during class discussions of problems students encountered while bike riding and traveling with parents through Watertown Square. Children began diagramming the square, labeling the various streets, and identifying the traffic problems. A trip was planned to observe the square and to gather necessary data for designing and constructing models of the area.

Often, work on one challenge leads to another. For example, students working on the Pedestrian Crossings challenge might find that the best way to solve a crossing problem is to reroute traffic through an intersection. They might then begin to investigate the best way to change the existing traffic pattern, leading to work on the Traffic Flow challenge by either the whole class or a group within the class.

Students in a sixth-grade class in Lexington, Massachusetts, conducted an advertising campaign for pedestrian safety in their school. Towards the end of the year they decided to focus on safety problems in the school driveway and parking area. A group of children conducted a survey of vehicles using the driveway and estimated their speed. Another group made scale models of the area and teachers' cars to use in working out solutions to the problems. The class ended their investigations by offering five suggested improvements to the principal.

When a class works on two or more related USMES challenges at the same time, children divide into groups to conduct investigations on the various problems. However, there should be at least ten to twelve students working on any one challenge; otherwise, the children's work may be fragmented or superficial or may break down completely.

The Traffic Flow challenge may also evolve from a discussion of a specific topic being studied by the class. For example, students studying transportation systems may observe local roadways; when they become aware of problem areas, such as bottlenecks or dangerous intersections, they may decide to collect data on these problems in order to propose helpful changes.

Sometimes the discussion of a broad problem may encompass the challenges of several related units. For example, a discussion of how they get to school can lead the students to the challenges for Traffic Flow, Bicycle Transportation, Pedestrian Crossings, or Getting There as the children identify specific problems.

A fourth- and fifth-grade class in Durham, New Hampshire, discussed the nature of traffic and what could

be learned about it. The class talked about pedestrian, bicycle, and automobile traffic. Children were most interested in auto traffic; they discussed experiences they had had while riding in cars with their families. The class focused on the town's central traffic area and the problems created by existing traffic patterns.

An experienced USMES teacher is usually willing to have the children work on any one of the several challenges that may arise during the discussion of a broad problem. While this approach gives the children the opportunity to select the challenge that they are most interested in investigating, it does place on the teacher the additional responsibility of being prepared to act as a resource person for whichever challenge is chosen.

Classroom experience has shown that children's progress on the Traffic Flow challenge may be poor if the teacher and students do not reach a common understanding of what the challenge is before beginning work on it. This is particularly true if the teacher introduces a broad problem and does not encourage the children to delineate a specific challenge. Having no shared focus for their work, the children will lack the motivation inherent in working together to solve a real problem. As a result, they may quickly lose interest.

Children in a fifth-grade class discussed problems they experienced in getting to school safely, including crossing dangerous intersections, riding bicycles without a pathway, and having long and crowded bus rides to school. The class divided into groups to work on different problems. Within groups, children collected data on flow of traffic and student crossing times, conducted opinion surveys on crossing problems and problems riding school buses, and constructed scale models of roadways. However, the problem was too broad and the groups were too small for any significant changes to result from their work.

A similar situation occurs if the teacher, rather than insuring that the children have agreed upon a Traffic Flow challenge, merely assigns a series of activities. Although

he or she may see how these activities relate to an overall goal, the children may not.

A fifth-grade class started work on the Traffic Flow challenge by discussing the meaning of "traffic." They were given road maps of the area and asked to solve problems using them. They took several walks to nearby intersections with a list of questions given them by the teacher. In trying to answer these questions, the children observed the traffic and counted cars. However, the teacher never issued a challenge to the children. Consequently, their work was never focused, and interest in the unit died out.

Students have the best success with the Traffic Flow challenge if they focus on a real traffic problem that is near at hand. Classes investigating a traffic situation that is in an area far from the school will usually become disinterested because children will find the problem too far removed from their personal experience to be sufficiently challenged.

Initial Work on the Challenge

Once a class has decided to work on a Traffic Flow challenge, USMES sessions need not be rigidly scheduled, but they should be held several times a week. When sessions are held infrequently, students often have difficulty remembering exactly where they were in their investigations and their momentum diminishes.

When students begin work on their challenge, they list aspects of the traffic flow problem in the area being investigated. This procedure is combined with or followed by preliminary observations of the problem area and/or opinion surveys to identify traffic problems that other people feel are critical.

Next, the students usually categorize their suggested approaches, grouping similar ideas together. The children then set priorities for the tasks they consider necessary to help solve the particular traffic problem. Most of these tasks are carried out by small groups of children.

Fifth-graders in Watertown, Massachusetts, worked on improving traffic problems in congested Watertown Square. After examining the area and listing the

problems that needed to be improved and the information they needed to obtain, the children divided into four groups to work on the challenge: (1) Interview Group I to interview pedestrians and store employees about the traffic problem; (2) Interview Group II to interview traffic and safety officials and drivers; (3) Timing and Measuring Group to time lights and pedestrian crossing times, count cars, etc.; and (4) Photography Group to take pictures of traffic problems.

As various groups complete their work, their members join other groups or form new groups to work on additional tasks. However, if too many groups are formed, work on the challenge can become fragmented. The teacher finds it impossible to be aware of the progress and problems of each group; in addition, the small number of students in each group lessens the chance for varied input and interaction.

Refocusing on the Challenge

As a class works on a Traffic Flow challenge, the children's attention should, from time to time, be refocused on that challenge so that they do not lose sight of their overall goal. Teachers find it helpful to hold periodic class discussions that include group reports on their investigations of traffic problems. Such sessions help the students review what they still need to do in order to recommend improvements for a roadway or congested area. These discussions also provide an opportunity for students to evaluate their own work and exchange ideas with their classmates. (Another consequence of having too many groups is that not every group can be given enough time to report to the class, thereby increasing the possibility that the children's efforts will overlap unnecessarily.)

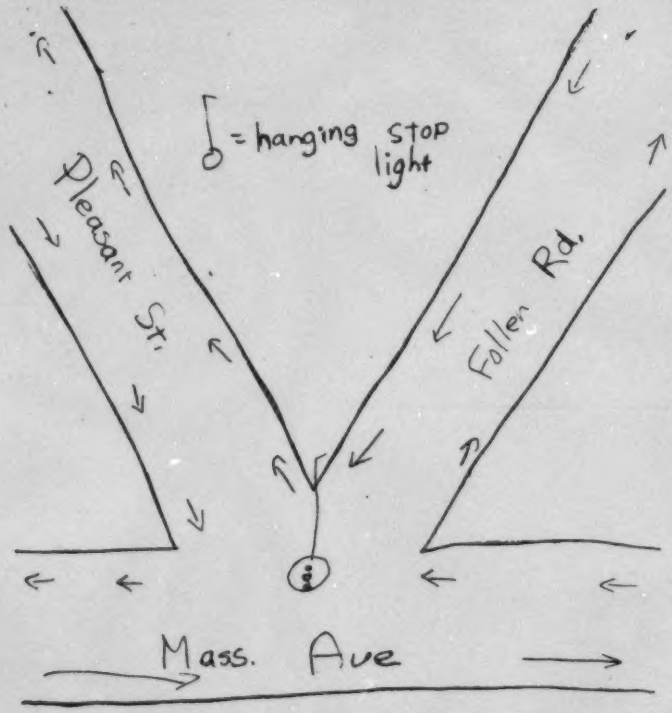
Students should keep in mind the real problem that they are working on while engaging in Traffic Flow activities. The theoretical nature of traffic movement and road design can easily turn the unit into a study topic unless the teacher is aware of the dangers involved. This is especially important when children construct scale models of existing traffic patterns and proposed changes for a problem area. Although model building is extremely helpful for students trying to choose from a number of possible traffic patterns, students should recognize that models only approximate a real life situation; they must consider all factors involved when deciding which traffic pattern is the best to recommend.

A sixth-grade class began Traffic Flow by examining a model of a hypothetical right angle intersection and discussing possible changes that could make it safer. They then decided to investigate a real intersection nearby that they felt was dangerous. After measuring widths of roadways, they broke into groups to construct scale models of the intersection that showed their solutions to the traffic problem. Most of the plans they developed involved extensive land-taking and relocation of families. When the children returned to the real intersection, they were less willing to recommend such solutions than they had been when they were dealing with a purely hypothetical situation. They proposed that a traffic light be installed at the intersection and a policeman be added at peak hours to direct traffic.

Resources for Work on the Challenge

When children encounter difficulties during their Traffic Flow investigations or try to decide on solutions before collecting enough data, an USMES teacher helps out. Instead of giving answers or suggesting specific procedures, the teacher asks open-ended questions that stimulate the students to think more comprehensively and creatively about their work. For example, instead of telling children that their solutions need data to support them, the teacher might ask how they can prove to others that a problem exists. Rather than tell the children that their ideas for rerouting traffic are impractical, the teacher might ask them how much each system would cost, how many families or businesses would need to be relocated, etc. Examples of other non-directive, thought-provoking questions are given at the end of this section.

The teacher may also refer students to the "How To" Cards relating to Traffic Flow for information about specific skills, such as using a stopwatch or drawing graphs. Often, many students or even the entire class may need help in particular areas such as calculating speeds of cars. Teachers should conduct skill sessions as these needs arise. Particular concepts may be learned in the context of investigating the problem; for example, use of angles to define the amount of curvature of a road can be learned during construction of a scale model. Other concepts, such as the relationship between speed of a vehicle and curvature of a roadway, can be learned by referring to familiar examples, such as what happens when a student rides a bicycle around a corner.



(From Bertha Wahl, Grade 6)

Figure B2-1

(Background Papers on Traffic Flow problems provide teachers with additional information on specific problems associated with the challenge. Other Background Papers on general topics may also be helpful.)

USMES teachers can also assist students by making it possible for them to carry out tasks involving hands-on activities. During work on the Traffic Flow challenge children may need to collect data along streets or at intersections. The teacher can help with scheduling and supervising during such data-gathering activities. If the children's tasks require them to design and construct items, such as trundle wheels or scale models of roadways, the teacher should make sure that they have access to a Design Lab--any collection of tools and materials kept in a central location (in part of the classroom, on a portable cart, or in a separate room). A more detailed account of the Design Lab may be found in the USMES Guide.

Valuable as it is, a Design Lab is not necessary to begin work on Traffic Flow. To carry out construction activities in schools without Design Labs, students may scrounge or borrow tools and supplies from parents, local businesses, or other members of the community.

A fifth-grade class in Washington, D.C., responded to the Traffic Flow challenge without using the Design Lab. Their investigations included the following activities: observations of three intersections near school; counting cars entering and leaving a complicated rotary; measuring the gap times of cars leaving the rotary along one street; observing traffic and measuring the widths of streets at an intersection; and writing to the city Traffic Division about their recommendations.

The extent to which any Design Lab is used varies with different classes because the children themselves determine the direction of the Traffic Flow investigations.

Culminating Activities

Student investigations on Traffic Flow generally continue until the children have agreed upon and recommended some solution for their traffic problem. Once they have chosen their solution(s)--a new road design, a system for rerouting cars or buses, or new traffic regulations--they will try to have them implemented by authorities. They may write let-

ters to traffic officials describing the data they have collected on the problem and recommending their change(s). They may follow up their letter writing by making presentations or holding informal meetings to discuss and demonstrate their findings. For example, scale models made by the students may be useful for simulating changes in traffic situations. If the traffic problem investigated involves a school bus route or traffic patterns in the school driveway or parking lot, the children may present their proposed changes to the principal or superintendent of schools.

If a solution has been implemented by authorities, students evaluate the effects of the changes by observing traffic patterns, by measuring speed, volume, or density of traffic, or by conducting attitude surveys among people affected by the changes.

3. USE OF TRAFFIC FLOW IN THE PRIMARY GRADES

This unit is most successful when tried at the intermediate and middle school grade levels. Children in primary grades (K-3) with limited experience riding in automobiles might have difficulty finding a Traffic Flow challenge that is a real problem for them. However, in a few exceptional cases, such as school buses delayed by traffic congestion or parked cars in school turn-arounds obstructing children's play, Traffic Flow problems may arise that can be acted upon by younger children.

4. FLOW CHART

The following flow chart presents some of the student activities--discussions, observations, calculations, constructions--that may occur during work on the Traffic Flow challenge. Because each class will choose its own approach to the challenge, the sequence of events given here represents only a few of the many possible variations. Furthermore, no one class is expected to undertake all the activities listed.

The flow chart is not a lesson plan and should not be used as one. Instead, it illustrates how comprehensive investigations evolve from the students' discussion of a Traffic Flow problem.

Challenge: *Recommend and try to have a change accepted so that the flow of traffic will be improved at a nearby problem location.*

Optional Preliminary Activities:

Other USMES Units:
- *Pedestrian Crossings*
- *Bicycle Transportation*
- *Getting There*

Study of transportation or urban problems.

Possible Student Activities:

Class Discussion: What problems do you have riding your bicycle or riding in a car or bus that are caused by traffic jams, speeding cars, etc.? Is there a particular place where the flow of traffic might be improved? How might we find out what improvements to suggest?

Study of maps and aerial photographs.

On-site observations--written and photographic documentations of traffic problems.

Class Discussion: What are the main problems at this location? How can we collect more evidence of these problems? What information can we collect from roadway observations? What can we find out from interviewing other people? How big a sample do we need? How do we choose our sample? Formation of groups to work on data collection.

Design and construction of measuring instruments.

Classroom trial of measurement procedures.

Data Collection: Measuring car and bus waiting times and times to travel from one point to another. Time and distance measurements for figuring speed.

Data Collection: Photographing or counting number of vehicles on a street at a given instant.

Data Collection: Measuring roadways for determining scale model dimensions.

Data Collection: Public opinion survey of existing problems and possible solutions.

Calculation of median waiting times, travel times, speed of cars.

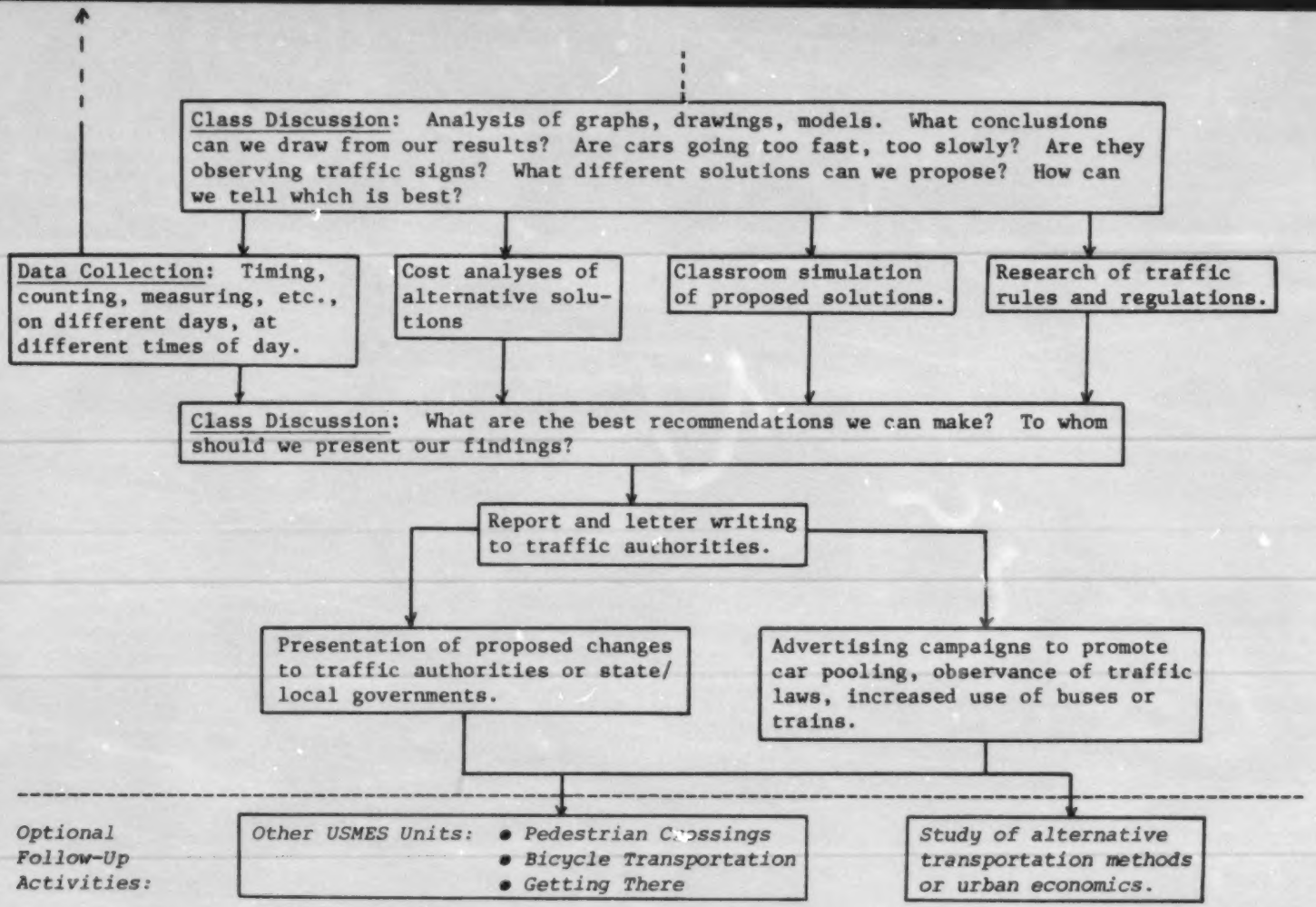
Calculation of traffic density.

Calculation of scale for model or drawings.

Data Representation: Preparation of bar graphs, histograms, scatter graphs, conversion graphs.

Design of scale drawings or construction of scale model.

Data Representation: Tally and histogram of survey results.


Class Discussion: Analysis of graphs, drawings, models. What conclusions can we draw from our results? Are cars going too fast, too slowly? Are they observing traffic signs? What different solutions can we propose? How can we tell which is best?
Data Collection: Timing, counting, measuring, etc., on different days, at different times of day.
Cost analyses of alternative solutions
Classroom simulation of proposed solutions.
Research of traffic rules and regulations.
Class Discussion: What are the best recommendations we can make? To whom should we present our findings?
Report and letter writing to traffic authorities.
Presentation of proposed changes to traffic authorities or state/local governments.
Advertising campaigns to promote car pooling, observance of traffic laws, increased use of buses or trains.
Optional Follow-Up Activities:
Other USMES Units:
• Pedestrian Crossings
• Bicycle Transportation
• Getting There
Study of alternative transportation methods or urban economics.

5. A COMPOSITE LOG*

This hypothetical account of an intermediate-level class describes many of the activities and discussions mentioned in the flow charts. The composite log shows only one of the many progressions of events that might develop as a class investigates the Traffic Flow challenge. Documented events from actual classes are italized and set apart from the text.

A teacher introduces the Traffic Flow challenge to her sixth-grade class during a discussion about the problem of getting to school on time in the morning. Several students have been late getting in because the school buses and parents' cars are frequently held up by traffic in front of the school. Other children who arrive earlier become impatient because they have to wait for the late arrivals before daily activities can begin. The late arrivals, on the other hand, protest that the situation is not their fault. One child says that he has asked the bus driver several times to let them off while they are stuck in traffic further down the street, but the bus driver says it's against rules: buses cannot unload until they are in the parking lot. Other children agree that it would hold up traffic even more to have a busful of forty students unload in the middle of the street and that this situation would be dangerous for the students as well. Other comments on the traffic situation are made:

"It's worst when it rains. Then it's backed up to Canal Street."

"They shouldn't let anybody on that street except people going to the school when it rains."

"No, that's stupid. You can't keep cars off."

"They should put a cop there. There's one in front where the walkers come in."

Everyone has his or her own ideas about how to solve the problem. However, the teacher says, "Before we talk to anyone about solutions, maybe we should find out more about the problem. How can we tell if there really is a problem?"

Children impatiently repeat some of the complaints that have already been made. Then one student volunteers to make a list of the different aspects:

1. Students are late getting to school.
2. A lot of time is wasted waiting for the bus to unload.
3. Cars can't get through the traffic in the morning and when school lets out in the afternoon.
4. Cars stop and let students out in the street or wait to pick them up (this holds up traffic even more).
5. There are no places to park during congested times.

*Written by USMES staff.

6. Rainy days are really bad because more kids are driven to school.

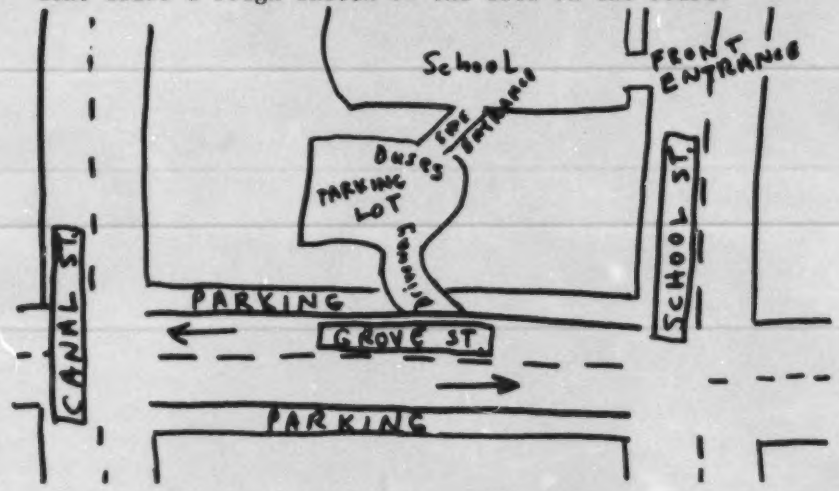
The teacher restates her question: "But how can we prove that these problems exist?"

"We can count cars," one student suggests.

"We can see how long it takes to get our class started in the morning," another adds.

"Let's make a map to show the congestion."

Other suggestions follow. During this part of the discussion, one child records suggestions while another student draws a rough sketch of the area on the board:



At this point the teacher asks them if they feel they can work on this traffic problem and come up with a solution. The class is overwhelmingly enthusiastic, and the teacher writes this challenge on the board: Try to have changes made in the flow of traffic on Grove Street so that cars and buses can get through more quickly before and after school.

A fifth-grade class in Arlington, Massachusetts, decided that something had to be done near a rotary on a major highway near the school. Accidents occurred regularly, and one of their classmates had been killed the previous year while crossing the highway. The children decided to form groups to observe the highway and to survey parents about the problem. (See log by Bernard Walsh.)

During the next class session, the first thing discussed is general dissatisfaction with the sketch one child has drawn on the board.

"The parking lot's drawn too small," one student says.

"How big is it really?" another asks.

"We need to measure it and draw a better sketch."

The class agrees with this suggestion. After much discussion and argument, a group is formed to measure not only the parking lot but the whole block, the width of the street, and the sidewalk leading from the parking lot to the school.

"What other groups do we need?" The teacher asks.

The class lists other information they need to show that the problem is serious:

1. Amount of time wasted on the bus
2. Number of cars using the street
3. Number of cars parked along the street
4. Amount of time it takes for a car to go from one end of the block past the school to the next street during congested periods

The class decides to form three more groups--the Bus Timing, Car Timing, and Counting Groups--and to call the first group the Measuring Group. The children break into these groups to figure out how the different kinds of information can be collected.

> *Students in a fifth-grade class in Watertown, Massachusetts, were asked what problems their parents had while driving through Watertown Square, about four blocks from the school. Students listed problems with traffic jams, illegal parking, and WALK lights not being long enough for crossing. Several children immediately wanted to build a model of the square. Other groups were formed to survey pedestrians, count cars on the streets coming into the square, and to time traffic light sequences and pedestrians crossing the streets. (See log by John Flores.)*

The children in the Bus Timing Group try to figure out how they can measure the amount of time wasted on the buses each day. They quickly decide that measuring time wasted

would be difficult because they have no standard time to compare with the longer times. One child suggests that they measure the amount of time spent on the buses from the beginning of the block to the time when they unload. The other children in the group like this suggestion. Since the entrance to the parking lot is roughly in the middle of the block, they agree that the distance traveled from the Canal Street intersection should be about the same as the distance from the School Street intersection.

They decide to hand out stopwatches to one person on each of the nine buses so that he or she can clock the time taken to get from the beginning of the block to the side entrance of the school. The children with stopwatches will also measure the times spent on buses while traveling from the parking lot to the end of the block in the afternoon of each day. Of the eight children in this group, four will collect times while riding on his or her bus; the other five buses in the school must be timed by volunteers from other classes who ride them each day.

The task of timing cars passing through seems even more difficult to plan. The children in the Car Timing Group realize that timing a car over a long distance would not be an easy feat. They finally decide to have two students collect starting times for cars at one street corner while two more collect finishing times at the end of the block (one student of each pair would operate the stopwatch while the other would record); the times could be subtracted to get travel time from one end of the block to the next. Everyone in the group agrees that not all cars passing through can be timed. After much argument, the children decide to time only VW "beetles." They plan to have a recorder at each end note the first two digits of the license number for each car so that they can match the beginning and ending times for each car. The group decides to collect times for ten cars before school in the morning, shortly before noon, and after school in the afternoon for a period of several days.

> *Students in a fifth-grade class in Washington, D.C., wanted to measure the speed of cars on a street near the school to find out how many were exceeding the speed limit. They decided that they must time cars over a certain distance in order to find speed. They began by measuring the distance between two poles in the sidewalk, using different measuring devices and averaging the measurements. Before timing cars, the students used a stopwatch to time*

each other walking and running between the poles. They calculated speed in feet per second, and then used the same method to time cars and calculate their speed. (From log by Audrey Robinson.)

The Counting Group is responsible for counting moving vehicles and vehicles parked along the street. The children quickly realize that although counting parked cars would be relatively easy, counting moving cars would be much harder. One student suggests that they count cars as they move past a certain point--the lamp post near the entrance to the parking lot. The rest of the group is interested in this suggestion. The teacher, who happens to be sitting in on this group's discussion, suggests that they try out this technique the following morning. Two children from the group volunteer to count cars to see how the method works.

When the group meets the following morning, the two children's report is discouraging.

"There was a big jam when we were there and the cars didn't move. There were a lot of cars but we only counted twelve going past the post in one minute," one student complains.

"We need a way to really show how many cars are in the block!" a student exclaims.

Everyone agrees that it would be nearly impossible to count the total number of cars along the street at once. Not only do the cars move during the time needed to count, but the whole street cannot be seen at once.

"I know!" says one boy. "We can do it from above! Let's go up to the third floor. You can see the whole block from Mrs. Peterson's room."

This still doesn't solve the problem of car movement during the counting time, however. At last, one student comes up with an idea that everyone agrees is brilliant.

"We can take pictures," he says. "Cameras stop cars in their tracks!"

The following day, several cameras are brought in. The children appropriate Mrs. Peterson's classroom during lunch time and test their method for measuring traffic density, as the teacher calls it. They quickly find that one camera will photograph one-half of the block; two are necessary to include all the cars on the block at one time. The group decides to use the photographs to determine the number of parked cars as well.

Two children volunteer to bring in their parents' tripods so that the fields of view could be set up carefully

before the pictures are taken. Because it is important to have the two photos taken simultaneously, the group decides to station one person at each camera while a third student gives the signal to shoot. They decide to take pictures three times a day for several days to collect enough data for documenting the congestion problem. (The children agree that the photos themselves could be useful as evidence of the problem.)

> *The fifth-grade class in Watertown, Massachusetts, decided to take pictures of the flow of traffic through Watertown Square to see if they could learn more about the traffic problems. They formed a group to photograph traffic bottlenecks and to film cars as they entered from different streets. Afterwards, they viewed their movie, examined the photographs, and used these visual records to help them pinpoint problems and propose changes in the traffic flow through the square. (See log by John Flores.)*

During a class discussion the groups make final plans for data-collecting. The class decides to complete trials of their methods of collecting traffic data the following week and then to devote two whole weeks to the actual collecting. To keep costs down, the Counting Group decides to take pictures only five days out of the ten; other data will be collected every day. All the traffic data collectors except the children taking times on buses will make their observations starting at 8:15 A.M., 11:15 A.M., and 2:30 P.M. during the school day.

Meanwhile, the Measuring Group has decided to make two trundle wheels to help them measure the length of the block, the width of the street, and the dimensions of the parking lot. The group works in the Design Lab constructing these instruments while the other groups are figuring out their methods.

The data-collecting sessions go fairly smoothly, although not without problems. For two days it rains and the children are unable to collect data outside. The class decides to have two "make-up" days the following week for the students working outside. Also, students forget six times to time buses coming to school in the morning and leaving in the afternoon, but because they plan to use averages, they feel the data they have will be sufficient.

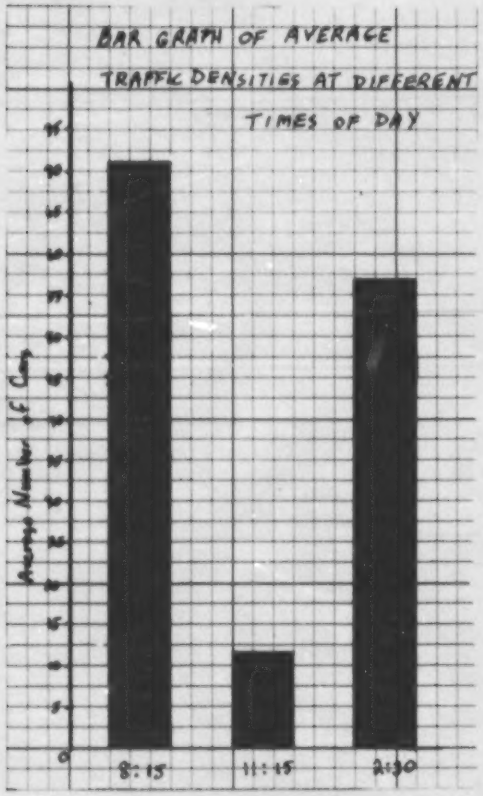


Figure B5-1

Students in the fifth-grade class in Arlington, Massachusetts, took a field trip to nearby Route 2 to measure the speeds of cars. After marking out a distance, the children worked out a signaling system for timing Volkswagens as they traveled this stretch of roadway. The children encountered some problems in the field, such as not being able to start the stopwatch on time, confusion as to which cars were being timed, and not being able to see when the car being timed had reached the finish line. They discussed these problems and their methods for calculating speed when they returned to the classroom. (See log by Bernard Walsh.)

Once the data has been collected, the students work in groups preparing their information to be shown to the other children. The children in the Counting Group count the number of cars in the traffic lanes (on both sides of the street) for each day; they add up all the daily tallies from the photos taken at 8:15 in the morning, then from those taken at 11:15, and again from the shots taken at 2:30 in the afternoon. They divide each set by the number of days (five) to find the average number of cars (traffic density) for each time period and then make a bar graph of the averages (See Figure B5-1).

After examining the photos and noting the number of parked cars, one student in the Counting Group says that she feels this information is not really important since "one parked car is as bad as a lot of them, because everyone has to move around it to get through." The children decide that the number of moving cars will provide enough information, and they do not count the parked ones.

The children in the Bus Timing Group examine their data on the time spent on buses between the beginning of the block and the school and wonder how to present all the pieces. The children have collected one set of times for buses coming into the parking lot and another set for those leaving in the afternoon. Each set contains between eighty and ninety pieces of data. (Data was collected for nine buses over ten days, except for the days when students forgot.)

The teacher asks the students working in this group what they plan to show with the information they have gathered. The students, after much discussion, decide that they would like to indicate the amount of time students spend waiting on buses over a whole year. They realize that this figure

will take a long time to calculate. At first, the group is uncertain whether to begin by calculating the average time for each bus or the average time for each day. They finally decide that if they find the average time per day for each of the buses, they can multiply each time by the number of students on that bus and add the results to find the total amount of time the students have spent waiting on the buses each day.

Meanwhile, the Car Timing Group is working on organizing and graphing the data on car transit times. They have collected times for ten cars going from School Street to Canal Street at 8:15, at 11:15, and at 2:30 each day. Originally, the children planned to time only Volkswagens, but they find that during the 11:15 session it takes too long to wait for ten Volkswagens to pass. They devise a hand signaling system that enables them to time other cars as well.

Since all times have been read off stopwatches that have been synchronized before the timing begins, the students must first subtract the School Street time from the Canal Street time to get the amount of time a chosen car takes to go from one end of the block to the other. One of the data sheets looks like this after the calculations are made:

Tuesday, November 5, 197-
Timing Period: 8:15-8:30

Car License Number	Canal Street Time	School Street Time	Car Travel Time
WRB	2 min. 45 sec.	3 min. 48 sec.	1 min. 3 sec.
CZR	3 min. 29 sec.	4 min. 38 sec.	1 min. 29 sec.
LSD	3 min. 51 sec.	5 min. 36 sec.	1 min. 45 sec.
CTJ	4 min. 38 sec.	6 min. 27 sec.	1 min. 49 sec.
JMK	5 min. 56 sec.	7 min. 30 sec.	1 min. 34 sec.
RTB	7 min. 19 sec.	8 min. 55 sec.	1 min. 36 sec.
LBN	7 min. 59 sec.	9 min. 16 sec.	1 min. 17 sec.
EZM	8 min. 16 sec.	10 min. 13 sec.	1 min. 57 sec.
SAS	9 min. 10 sec.	10 min. 54 sec.	1 min. 44 sec.
FXG	11 min. 28 sec.	13 min. 15 sec.	1 min. 47 sec.

The students change all these car travel times into seconds, then calculate the times in seconds for the other twenty-nine observation periods. After reviewing the "How To" Cards on histograms, they make three histograms, each showing data on one hundred cars. The histogram showing the times it took cars to travel the one block during the

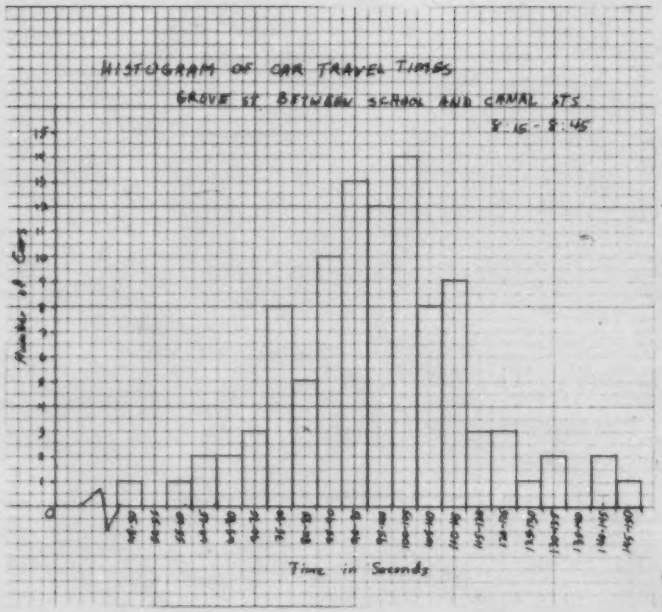


Figure B5-2

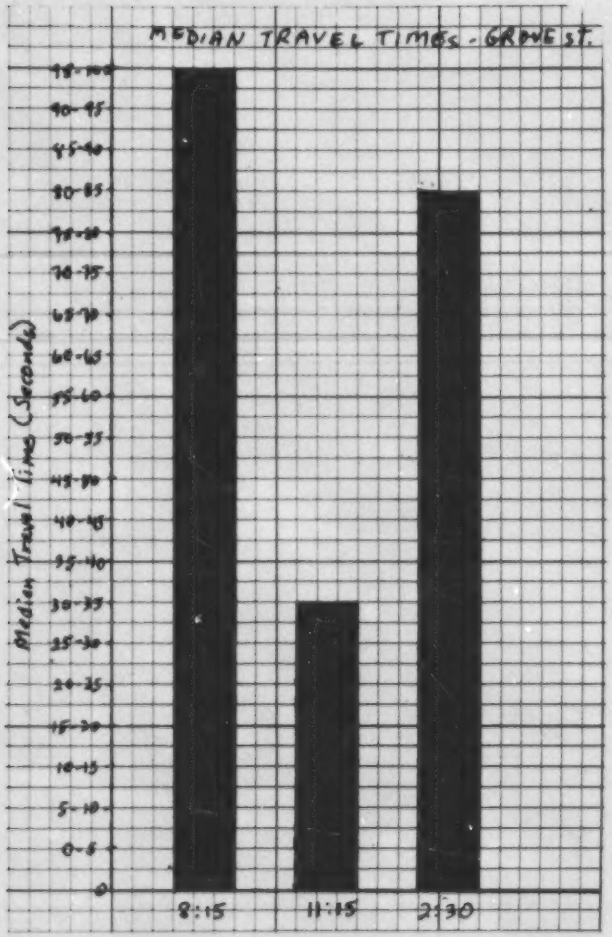


Figure B5-3

8:15 period is shown in Figure B5-2.

When the histograms have been made, the children use them to find the median travel time for each timing period. They find that the median time for the 8:15 period is 95-100 seconds; for the 11:15 period, 30-35 seconds; and for the 2:30 period, 80-85 seconds. In order to show this information to the class, the group makes a bar graph of the median travel times. (See Figure B5-3).

> *Besides taking movies and photographs, the fifth graders in Watertown, Massachusetts, collected several kinds of data on their trips to Watertown Square. Two groups taped interviews with pedestrians, drivers, officials, and other people. Another group counted the number of cars coming into the square, measured widths of streets, timed the length of red lights, and timed pedestrians crossing the street. Back in the classroom, the children discussed different kinds of graphs and decided to make bar graphs of their findings. After making some preliminary graphs on the board, the children worked in groups graphing their results on large pieces of paper. Later, they took another trip to the square to collect additional information, which they used to make new graphs for discussion and display. (See log by John Flores.)*

While the data-collecting groups have been organizing and graphing their data, the Measuring Group has completed their measurements of outside distances and is busy making a map to scale. They have chosen the scale of 1 cm ⟷ 5 m and are busy converting their measurements in meters to centimeters for the map.

When graphs and the map have been completed, three of the groups present their information to the whole class. The children examine the graphs and comment on the information each group has presented.

"The average number of cars on Grove Street is seventy-one at 8:15 A.M. and twelve at 11:15 A.M. That's a big difference!"

"One morning there were eighty-four cars on the street at once. For a street 304½ meters long, that's a lot of cars!"

The children also comment on the number of cars that use the street at different times of day and the time it takes them to go past the school. They note that it takes sixty-

five seconds longer to travel past the school on Grove Street at 8:15 A.M. than at 11:15 A.M. and fifteen seconds longer at 8:15 A.M. than at 2:30 P.M.

The children discuss the school traffic problem they have documented and decide what to do about it.

"Let's ask the principal to put a cop there in the morning and the afternoon," someone suggests.

A long discussion of the different changes that could be made follows this comment. Alternative suggestions are listed on the board:

1. Make street one-way in morning and afternoon.
2. Widen street to take more cars.
3. Add an entrance to the parking lot in the back.
4. No parking on one side of street.
5. Policeman or woman to direct traffic.

One student suggests that the class take a vote on the different recommendations, but another child requests that they check costs of the various alternatives before making a decision. When the class agrees, several children volunteer to form the Research Group. The function of this new group is to collect estimated costs for the five alternatives from the local Department of Public Works.

Children in a sixth-grade class in Lexington, Massachusetts, worked on alternative solutions to a traffic problem at a nearby intersection. They made models of the alternatives, which they presented to the rest of the class. Many of the plans involved extensive land-taking and relocation of families. The children felt these plans were too costly and they decided to concentrate on two suggestions: installing an overhead traffic light and having a policeman direct traffic during peak hours. They tried to compare these solutions by researching their costs. They were able to find out how much a policeman would be paid for his labor, but they never received a reply from the state traffic division on the cost of a traffic light. (From log by Bertha Wahl.)

After examining the map made by the Measuring Group, the class decides that it will be easier to plan changes and to assess the various alternatives if they can actually look at a representation of the school area. They decide to use the map to construct a Tri-Wall layout to scale. Several students volunteer to work on this project in the Design Lab. When they have finished constructing the layout, they add toy trees, buildings, and cars to make it more realistic.

> *Students in the Arlington, Massachusetts, class made sketches and constructed models in the Design Lab of their problem roadway, Route 2, and the way they would like it to be improved. They spent a great deal of time discussing the best angles of entry and exit onto the highway. They drew different types of entrance and exit ramps on the floor and compared them, then used the best one as the design for a model of their "future Route 2." The children also built other models of real and hypothetical traffic situations. (See log by Bernard Walsh.)*

While the rest of the class works on cost estimates and the scale model, the Bus Timing Group makes the estimate of time spent on school buses between the beginning of the congested block and the school over the whole year. Once the average time lost over the ten-day period has been calculated for each bus from their data, the children obtain a list of the number of children on each bus from the office; they multiply these figures by the corresponding time per day for each bus. A sample calculation is shown below:

$8\frac{1}{2}$ minutes--average time spent waiting on bus No. 9 each day (rounded off)
x 31 students
$263\frac{1}{2}$ minutes for all students riding but No. 9 each day

The children add the total student time spent on all the buses, and then multiply the sum of the ten figures by 180, the number of school days in a year. They come up with the astonishing figure of 517,320 minutes, or 8,622 "student hours" spent over an entire school year by children waiting in buses near the school!

During the next class discussion, the children use the completed scale model to discuss possible changes in the flow of traffic on Grove Street. Most children agree

that widening the street, which means moving trees on one side, or building a new entrance to the parking lot, which means relocating part of the playground, do not seem to be very practical suggestions. The economic figures of the Research Group bear out these observations: both suggestions are too expensive.

Several children favor getting a policeman or police woman to help direct traffic, but most of the class agrees that this will not solve the problem of high traffic density before and after school. However, the children decide that if parked and stopped cars were removed from the side of the street opposite the school, cars would have less trouble getting through. They plan to recommend changing the parking regulations as a solution.

When the children discuss making the street one-way, they realize that they have to take into consideration how parallel streets will be affected by additional traffic. The Scale Model Group has not bothered to measure the two streets on either side of Grove Street. Now they go outside to measure length and width of the street and to add these dimensions to the scale model. They find that the streets are approximately the same width as Grove Street. The students also note that there are not as many cars on these streets as there are on Grove Street. After serious discussion, the class decides that both streets can absorb the additional traffic if Grove Street is changed to a one-way street.

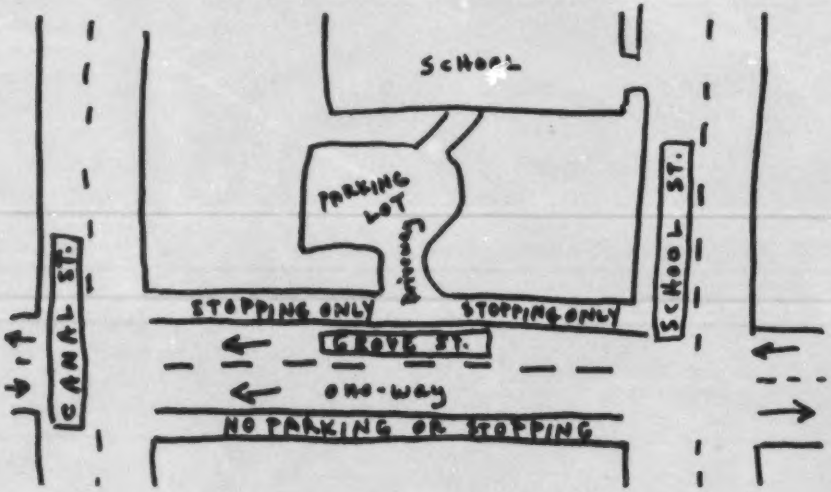
> *Once the children in the Watertown class had collected enough traffic data, they talked about possible changes to the problem in Watertown Square. Working in groups, they drew up plans and made scale models of the square which indicated their changes. Each group also wrote a report justifying their plan. The models were displayed in the school lobby and a local newspaper report on the children's work publicized their criticisms and proposed changes. (See log by John Flores.)*

During a class discussion the children decide to inform the principal of their recommendations. They write a report that includes their data and graphs and conclude it with two recommendations:

1. Grove Street should be made one-way from 7:45 A.M. to 8:30 A.M. and from 2:15 P.M. to 3:00 P.M. A police patrol should put up and take down the sign.

2. There should be no parking and no stopping on the opposite side of the street from the school between those hours. This way traffic can get through. Stopping should be allowed on the side near the school, but not parking.

The diagram below shows the children's proposed changes:



The class decides to ask the principal to read their report and view their model. The principal comes into the class to talk to the children about their results. She suggests that the children send a letter containing their recommendations to the head of the city Traffic Department. A group of children draft a letter and the whole class refines the draft during a discussion. The letter is sent with a copy of the report to the Traffic Department. The children receive a reply about a week later indicating that a representative of the department will visit the class to talk about the proposed changes.

When the traffic official arrives, the children show him their scale model and explain how they arrived at their proposal. They ask him for a trial run to see whether making the street one-way and eliminating parking on both sides and stopping on one side would be feasible. He replies that the decision must be made by the head of the Traffic Department, but that he would recommend that the children's suggestion be put into effect. He adds that the department already recognizes the need for a change in existing traffic patterns on this street.

The children in the Arlington class decided to recommend an overhead pedestrian crosswalk for Route 2 because they felt that lowering the speed limit or putting in a traffic signal would be impractical on a high-speed road. They also made a model of their final recommendations for changing the flow of traffic at the traffic circle. The following year, a pedestrian overpass similar to the one proposed by the children was constructed based on traffic studies by the town government. (See log by Bernard Walsh.)

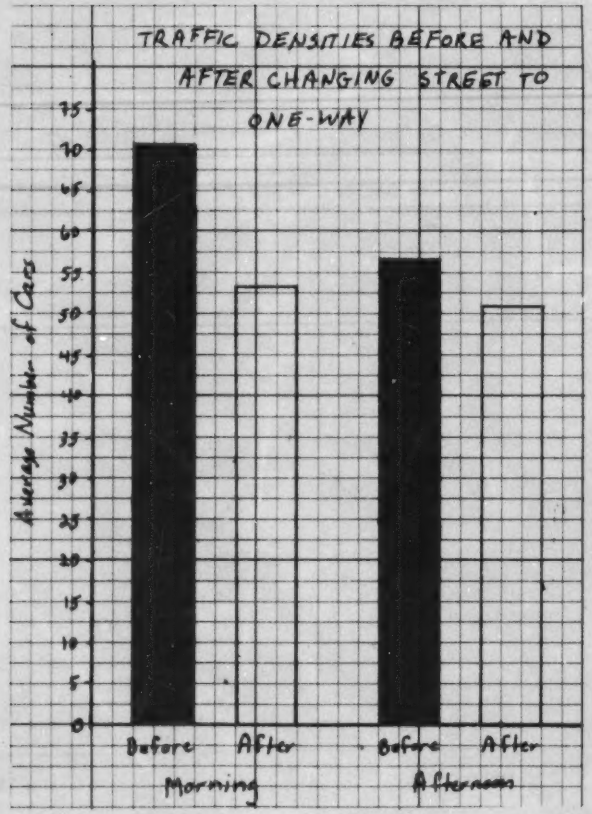


Figure B5-4

A few days later the children receive word that a two-week trial run of their proposal will be held to see if the traffic situation can be improved. The Traffic Department will also have a policeman sent to see that the regulations are enforced. The class decides to collect data during this trial period to document improvements in the flow of traffic. The children decide to photograph traffic density before school and after school for five of the trial days and to compare this data to the earlier set of photographs. They also decide to measure time wasted on the bus and transit time for cars going past the school for comparison to previously collected data.

During the trial period, the data collecting goes quite smoothly since the children are now proficient in timing and photographing vehicles. The children timing cars notice that through traffic is using the left-hand lane much more than the right-hand lane. Those cars going through in the right-hand lane usually pull into the left lane to avoid school traffic. Some children who are watching the traffic flow on the two streets parallel to Grove Street agree that there seems to be more traffic than before but that the streets do not appear congested.

After the trial period the children discuss their observations and organize their data. Most of the children are sure that the traffic situation has improved, but they still feel the need to make graphs and calculations to document the improvements. After the children in the Counting Groups tally cars and find average densities from the photographs of traffic density, they calculate a decrease of 26% in the average number of cars on the street during the morning and one of 11% in the average number of cars in the afternoon, when the street is one-way. Figure B5-4 is their bar graph documenting the changes. Children also prepare histograms of car travel times on Grove Street during the morning and afternoon periods. They find that

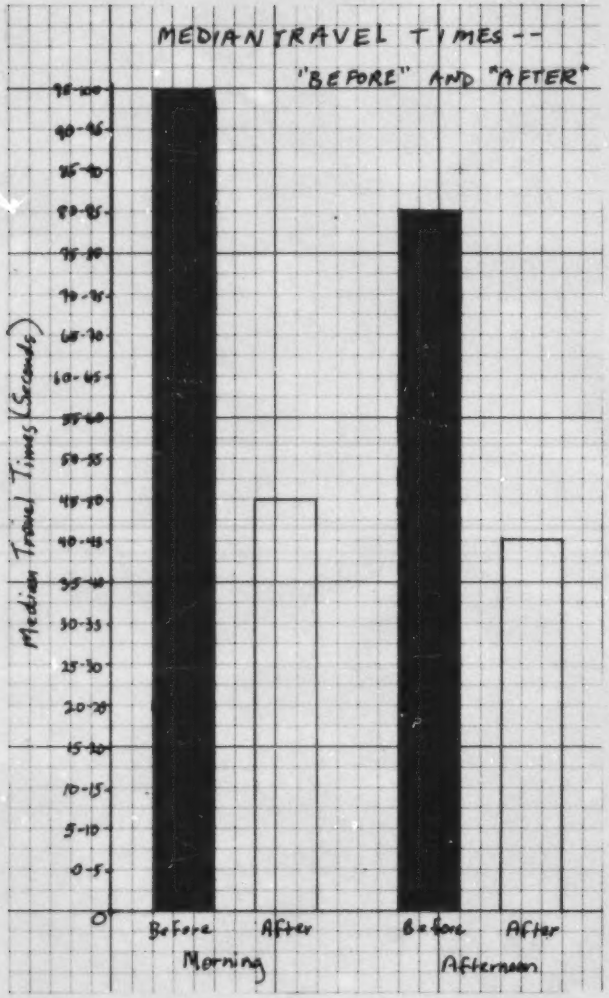


Figure B5-5

the median travel time for through traffic has decreased from 95-100 seconds to 45-50 seconds in the morning and from 80-85 seconds to 40-45 seconds in the afternoon, and they make a bar graph showing this decrease (see Figure B5-5).

The children responsible for measuring time spent waiting on school buses calculate average time lost over the ten-day period for each bus. Although most times seem shorter, there seems to be certain buses that still take a long time to unload. The children feel that this is because a number of buses seem to enter the parking lot together in the morning and sometimes have to wait while others unload. Using the same methods they have devised for the "before" data, they calculate the total time spent waiting on the bus projected over a school year to be 6,461 student hours, a decrease of over 25%.

The children write up their comparisons and present them to the Traffic Department. The traffic officials have also made studies and feel that the change would be beneficial to the traffic patterns in the community. The children are informed of a long-range plan to build an exit to the parking lot onto Canal Street which would involve relocating the playground to the other side of the school.

The following week, the new traffic regulations go into effect for the rest of the school year. The children help advertise the changes to the rest of the school. They also try to explain the new rules to adults and other students who feel inconvenienced by the one-way street and parking restrictions.

6. QUESTIONS TO STIMULATE FURTHER INVESTIGATION AND ANALYSIS

- What streets (driveways, parking lots) near the school do your parents or the school bus have trouble driving through?
- What streets have a lot of accidents on them?
- What do you think causes the heavy traffic and/or the accidents in these places?
- What information do we need in order to prove that a problem really exists? How can we get this information?
- How can we find out what other people think of these traffic problems?
- How can we best organize ourselves to collect the data we need?
- What is a good way to measure the amount of traffic?... the speed of the cars?
- How can we "stop action" to count cars that are in a section of roadway at a certain time?
- How can we tell how much time people waste when they're stuck in traffic jams?
- How can we tell at what time of day traffic is the heaviest?
- What is a good way to keep a record of our data?
- What is a good way to show other people the data we have collected?
- What kinds of graphs would best present the information we have found out?
- How could traffic regulations be changed to make the traffic flow better?
- How can we change the streets (parking logs, driveways) so that congestion or traffic accidents are decreased?
- Which design for changing traffic flow do you think would cost the least? How could you find out?

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- Which road design would take up the least space or cause the least dislocation of homes and businesses?
- How could we try out these different designs to see which is best?
- How can we prepare our information for presentation to other people so they will be convinced that our changes might work?
- Who should we contact about changes in the school parking lot or driveway? What would be the best government agency to contact about changes in traffic controls or regulations?...road designs?
- How can we convince people to try our changes?
- Now that our change has been carried out, how can we tell if it is working successfully?

Raymond School
Washington, D.C.
March 9, 1972

Traffic Division
Washington, D.C.

Dear Sir!

We would like to-
know if you would
please make 19th St.
bet Spring N.W. and
Quincy one-way because,
the traffic is very
heavy. And children
run off of hills into
the streets. So that's
why we've asked this
wonderful favor

Your's truely
Mary Spencer

(From Audrey Robinson, Grade 5)

Figure B6-1

C. Documentation

1. LOG ON TRAFFIC FLOW

by John Flores*
Hosmer School, Grade 5
Watertown, Massachusetts
(September 1972-June 1973)

ABSTRACT

Children in this fifth-grade class concentrated on how they could improve traffic flow and pedestrian safety in a local center, Watertown Square. After drawing a map of the area and listing questions to be answered in their investigations, the students divided into groups to interview people about the traffic problem, to collect traffic data, and to photograph and film the area. The data group measured the widths of streets and traffic islands, timed traffic lights and pedestrians crossing at different points, and counted cars coming into the square. When the groups had gathered enough information, they plotted their results on graphs. Then they returned to the square to collect additional information that they thought was needed. The children discussed what changes they felt should be implemented, including overpasses, a tunnel, and an additional street through the central island. Each group made a model of the square incorporating their recommended changes. The models were displayed in the school, and the local paper published an article on the children's research and conclusions.

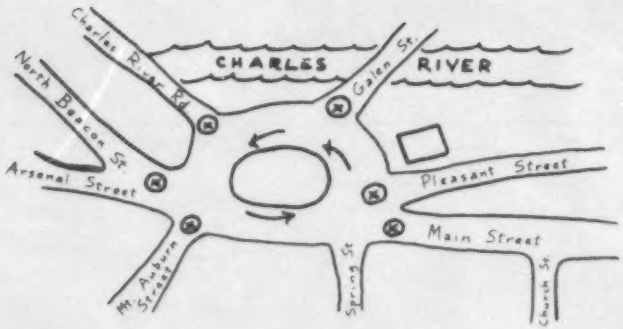


Figure C1-1

I introduced Traffic Flow to my class during a discussion of the problems they encountered riding their bicycles and traveling by car with their parents through Watertown Square. The children came up with the following list of problems:

1. Traffic does not flow continuously.
2. Parking, both legal and illegal, slows the flow of traffic.
3. Pedestrians don't have enough time to cross.
4. Lights are timed badly; some are too long, others too short.

*Edited by USMES staff

To this list they added the special problem Watertown Square poses for blind pedestrians. The square is close to the Perkins School for the Blind and is equipped with a special system of bells so that the many blind people in the area can travel by themselves and still cross safely. The kids felt that this system was confusing for the blind pedestrians, however, and more a hindrance than a help.

The class decided to draw a map of the square on the board to help in the discussion. They talked about the layout of the area, drew and labeled all the streets, and marked the locations of the traffic lights with X's and the central traffic island with a circle. Their map looked something like the sketch in Figure C1-1.

By locating trouble spots on their map, the children reviewed the problems they had listed. They were excited about the challenge during this first session and responded with a spirited "we'll show 'em" attitude.

During the next session the students expressed the feeling that they did not know enough about the square to identify all the problems. They began talking about what information they needed and how they could obtain it. They decided that they should ask different people what they thought about the situation and also make scientific observations of the area. They listed their ideas on the board:

Things to Find Out

1. What do pedestrians think about the situation?
2. What do drivers think about the situation?
3. What do policemen think about the situation?
4. What do employees in stores around the square think?
5. What does the Highway Department think about the situation?
6. How many traffic lights are there in the square?
7. How long are the lights red?...green?...yellow?
8. How long does it take to cross at different crosswalks?
9. What is the distance across the streets at the crosswalks?
10. How many cars enter and leave from the different streets?
11. What causes accidents in the square?

Several children also suggested taking photographs and movies of traffic in the square to provide concrete evidence

of the problems. Two boys started making a model of the area out of wood and clay to use in the discussions.

The next time the class worked on Traffic Flow they focused on how they would obtain the information they needed. After much discussion, they set up four task groups:

Group 1: Interview pedestrians and store employees

Group 2: Interview policemen, meter maids, firemen and drivers

Group 3: Time lights and pedestrian crossing times, measure widths of streets, count number of cars entering and leaving on different streets

Group 4: Photograph traffic problems

The students then discussed what equipment and tools each group would need to do its job. Then each child chose the group with which he or she wanted to work.

Groups 2 and 4 turned out to be more popular than 1 and 3. Because the class felt that each group needed roughly the same number of people to do its job well, we decided to think about what type of person would work best in each group and then redistribute the children among the groups.

After thinking the problem over, the children concluded that the class members who were not afraid to interview people should be in the interviewing groups and that the others should do the other tasks. They had trouble deciding who was not afraid to interview, however, and continued to have difficulty dividing themselves among the groups. In the end I had to assign some children to groups. The class decided that this was the only way to solve the problem.*

The children met in groups and planned their strategy for the trip to Watertown Square. Each group member was assigned a job by the group. In some cases children found it

*Another solution might be for children in the largest groups to draw lots so that a certain number are chosen to go to smaller groups. If some groups are more popular than others, the children might decide to switch tasks at some point; in that way, everyone might have a chance to participate in a more enjoyable task. --ED.

Good afternoon ma'am.

We are from the Homer School and we are studying the traffic problem of Watertown Square. If you have time, would you mind answering a few questions?

1. What do you think about the parking problem of Watertown Square? What about the traffic?
2. Which do you think is worse, the parking or the traffic? Why?
3. Do you have any ideas on how to stop these problems?
4. Do you think that the cross walk lights give you enough time to cross the street?
5. When you come here to shop do you have trouble finding a parking space?
6. Is there ever so much traffic that you can't get through?
7. Do you think that there should be more parking spaces?

Figure C5-2

hard to agree on who would do what. By thinking about what a job involved and how each student felt about it, they eventually came to a reasonable division of labor.

Each group decided what equipment it needed for the trip to the square. The interview groups requested cassette tape recorders; the Photography Group requested still cameras and 8mm movie cameras; and the Timing and Measuring Group requested stopwatches and measuring tapes. We assembled all this material from that available at the school and that which the students could bring from home. Each group became familiar with its equipment before setting out for the square. The interview groups also prepared lists of questions like the one in Figure C1-2.

The class went to Watertown Square at eleven o'clock one day in late October. Each group set about its tasks as outlined above. Group 1 taped interviews with pedestrians and store employees. Group 2 taped interviews with drivers and police officials. Group 3 (a) counted the number of cars coming into the square from each street for five minutes and noted the street onto which they exited,* (b) measured the distance across the streets at the crosswalks and the distance around the central traffic island, (c) timed the duration of the red lights, and (d) timed pedestrians crossing at different places. Group 4 filmed the traffic flow as cars entered from different streets and took photographs of traffic trouble spots.

In the classroom the children viewed the videotape and then discussed what they could do with the raw data they had collected. They decided they needed to make another trip to the square to complete their activities, but they felt they should wait until after they had sorted the information they had already collected.

The Timing and Measuring Group reported that they felt measuring long distances with tape measures was not reliable. I referred them to the "How To" Cards on measuring distances, and they discovered the value of the trundle wheel. They then found out that we had a commercially-made trundle wheel in the school. They examined it closely, tried it out, and then started building one for themselves.

*Observation at several times during the day would show variations in the traffic volume and subsequently in the speed of the cars. See Background Paper, *DP14 Speed, Travel Time Volume and Density Relationships in Traffic Flow*.--ED.

Traffic flow problem of Mat Sq.
parking is bad 1✓ 2✓ 3✓ 4✓ 5✓ 6✓ 7✓ 8✓
traffic is bad 1✓ 2✓ 3✓ 4✓ 5 6✓ 7 8✓
parking is fine 1✓ 2✓ 3 4 5✓ 6 7 8✓
traffic is fine 1 2 3✓ 4 5 6 7✓ 8
both 1 2 3 4✓
lights are enough time 1✓ 2 3✓ 4✓ 5✓ 6 7 8
enough parking spaces 1✓ 2✓ 3 4✓ 5 6 7 8
more parking spaces 1 2✓ 3 4✓ 5✓ 6✓ 7✓ 8✓
Signal lights bad 1 2 3 4 5 6✓ 7 8

Figure C1-3

Figure C1-4

Since we were dealing with measurement during math sessions, the Timing and Measuring Group introduced the rest of the class to the real measuring problems they were encountering. The group had measured the circumference of the traffic island at the square, and the class used this example as the basis for discussion of the meaning and use of circumference and diameter.

During the next USMES session the groups worked separately sorting the information they had gathered during their trip to the square. The interview groups listened to the tapes of the interviews and tallied the number of different responses to each question. A copy of one student's initial tally sheet is shown in Figure C1-3. He assigned a number to each of eight people interviewed and then checked that number if that person made the particular response in question. Then the group members summarized their findings in paragraph form. They wrote informal reports on their results like the one in Figure C1-4.

Watertown square is a mess. the lightings wrong. not enough time to cross the street, to many cars, traffic jams to main st & on main St, to many islands. People cooperated Because ~~there~~ they so consered about it. Watertown doesn't have the worst traffic problem but it awFull over 100 cars come in every day from each st. Out of town and in Massachusetts 12/13 hate parking. 7/9 think the traffic is bad, that live in Watertown. We went down Friday October 20, 1972. I don't think the traffic was that bad that day.

The Timing and Measuring Group compiled and compared their different pieces of data and then discussed possible reasons for the differences. The Photography Group collected their rolls of film and made plans for having them developed.

Later, we met as a class to discuss the best way to present the findings of the interview groups and the Timing and Measuring Group. Several students suggested making booklets and reports, while others opted for drawing graphs

and diagrams. After talking it over at length, they decided that graphs might be best since they would not only show all the data but would also be easy to read. We went on to discuss different kinds of graphs, focusing on bar and line graphs. We talked about how to draw and label graphs and how to decide what size to make the intervals between the numbers on the axes.

During the next USMES session we worked on graphing our findings. The children decided to draw two graphs on the board first, one showing the crossing times at six different crosswalks in the square and the other showing the number of people citing different causes for the problems in the square. In figuring out how to number the vertical axis for the first graph we had the following discussion:

Teacher: How are we going to number to show the exact number of seconds?
Student: Go by ones.
Student: We might not have enough room.
Student: Then we can go by tens.
Student: Or by fives.
Student: And we can still write the exact number over the bar if we want.

The students decided to count the number of squares first when making their own graphs. Then if the biggest number they had were smaller than the number of squares, they would use intervals of one. If it were bigger, they would try intervals of two, and so on.

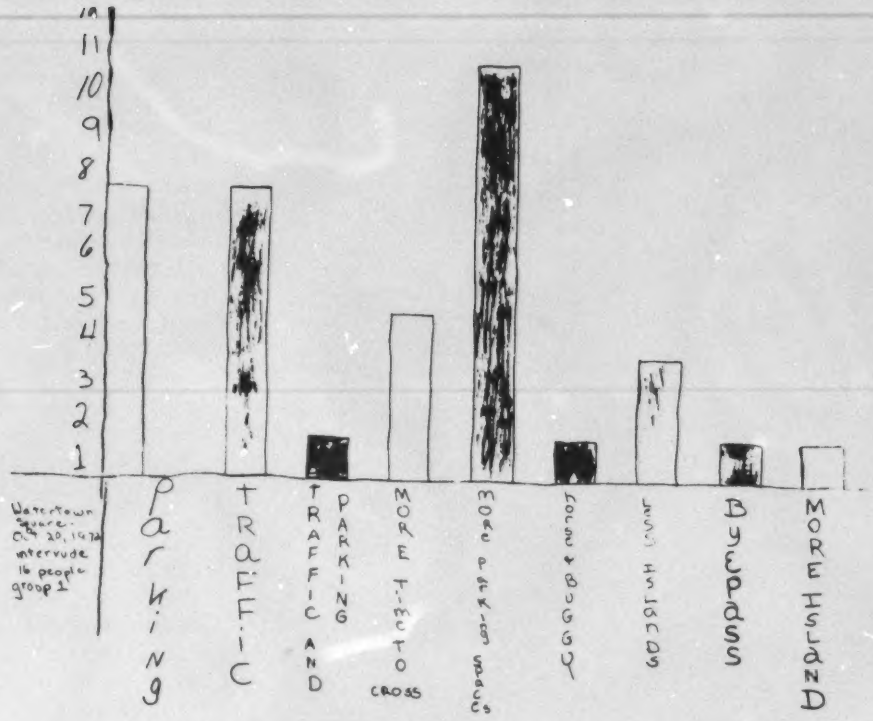
When they had finished making the graphs on the board, we talked about adding some important finishing touches:

Teacher: There's something missing from the graphs.
Student: People won't know why we did it or where we did it.
Student: We'll have to put down "Watertown Square."
Student: And the date.
Student: And tell why we made each graph.
Teacher: Why did you?
Student: To show the amount of time...
Student: To cross different places.
Student: And how many people gave different reasons for the traffic mess.

When they added this information, the finished graphs resembled the ones shown on the next pages.

The children worked in groups graphing the rest of their findings on large sheets of graph paper. Each of the two interview groups made a graph of the number of people citing different reasons for the traffic problems in the square. Since Group 1 had also asked for suggested improvements, the children in this group graphed the number of people offering different suggestions as well. One of their graphs is shown in Figure C1-5.

Figure C1-5



The Timing and Measuring Group organized the rest of their data and drew three different graphs. One showed how many seconds the crossing light stayed on at six different crosswalks. This graph is shown in Figure C1-6. Another graph showed the distance in feet across the streets at each of the six crosswalks. A third showed the number of cars entering and leaving Watertown Square via three different

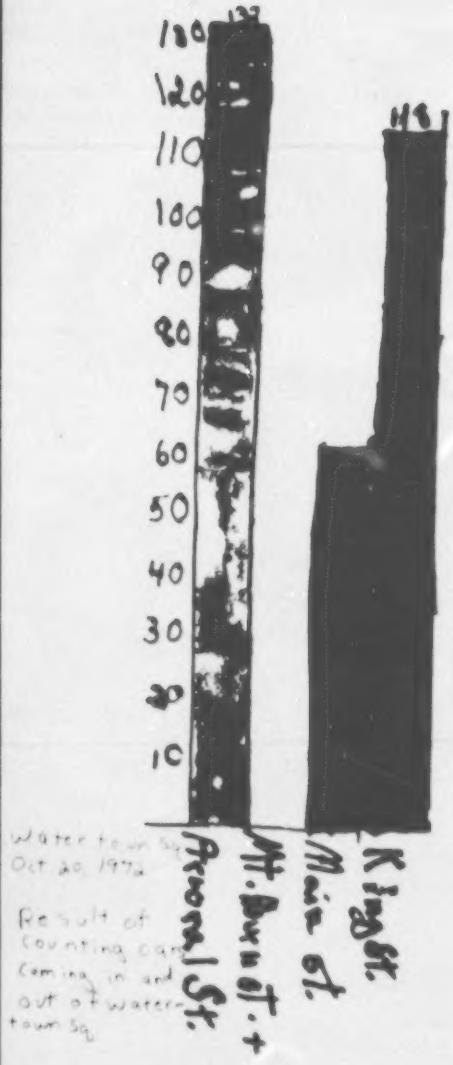


Figure C1-6

streets. (See Figure C1-7.)*

Meanwhile, the Photography Group worked on making a visual display of the traffic situation in the square. They organized and labeled the photographs and edited the 8mm film.

After they had finished their graphs, the students began suggesting changes to improve the traffic situation. Many felt that either an overpass or an underpass was the only change that could help. Others asked about the cost of such a plan, pointing out that it might be too expensive to be considered seriously. Supporters of the plan decided to contact engineering firms for information on costs and feasibility.

When the students had reviewed all the information they had gathered and graphed, they decided that they needed another trip to the square to fill in some gaps and to check some data. The interview groups rewrote some of their questions to eliminate simple yes or no answers. The Timing and Measuring Group decided that they would use the trundle wheel to remeasure the crosswalk distances. They also planned to recount the number of cars entering and leaving the square. The Photography Group discussed the shots that they needed to complete their film.

With the jobs assigned, we set out for the square again one morning in early December, undaunted (at least to begin with) by the subfreezing temperature. Group 1 taped interviews with store owners, taxi drivers, and shoppers. Group 2 taped interviews with more traffic and parking officials. Group 3 recounted cars entering and leaving via different streets and remeasured the crosswalks with the trundle wheel. The Photography Group finished making their film and then helped me videotape the others at work.

Back in the classroom the students went immediately to work organizing their data. They graphed their findings and then compared them to the first set of graphs. They were happy to find the results from the second trip consistent with those from the first.

The children decided that they had collected enough information and should move on to recommending changes. Some students first suggested that some of the streets be made one-way, but most felt major construction was necessary. The kids divided into groups according to the recommenda-

*They might also construct a traffic flow pattern for the square; see Background Paper, *DP 13 People and Space*. --ED.

tions they supported and began formulating more detailed proposals. One group recommended an overpass from Mt. Auburn Street to Galen Street. Two other groups, which had obtained rough estimates of the cost and feasibility of such major construction, came up with another alternative. They decided to recommend the construction of a street through the central traffic island so that traffic traveling from Mt. Auburn Street to Galen Street could drive straight through and avoid the rotary traffic.

The children then decided that each group should make a scale model of the square including the recommended changes. For the next two months the class worked on this project. First they drew plans and diagrams and decided on materials for the model. Then they went to the Design Lab and began learning how to use the tools while constructing their models. They measured, sawed and glued Tri-Wall and other materials together and finally added the finishing touches to their models with paint. Several groups also built electrical circuits into their models to support traffic light and bell systems. Sketches of the models are shown in Figure C1-8.

After they had finished their models, each group wrote a report summarizing the class findings and justifying their recommendation. The models, with the reports attached, were displayed in the main lobby of the school at the end of the year and stimulated a great deal of interest in the traffic problem within the school and the neighborhood. Parents, teachers, and other classes came to see the work and discuss the problem. The local newspaper also published an account of the class project, spreading the information further into the community.

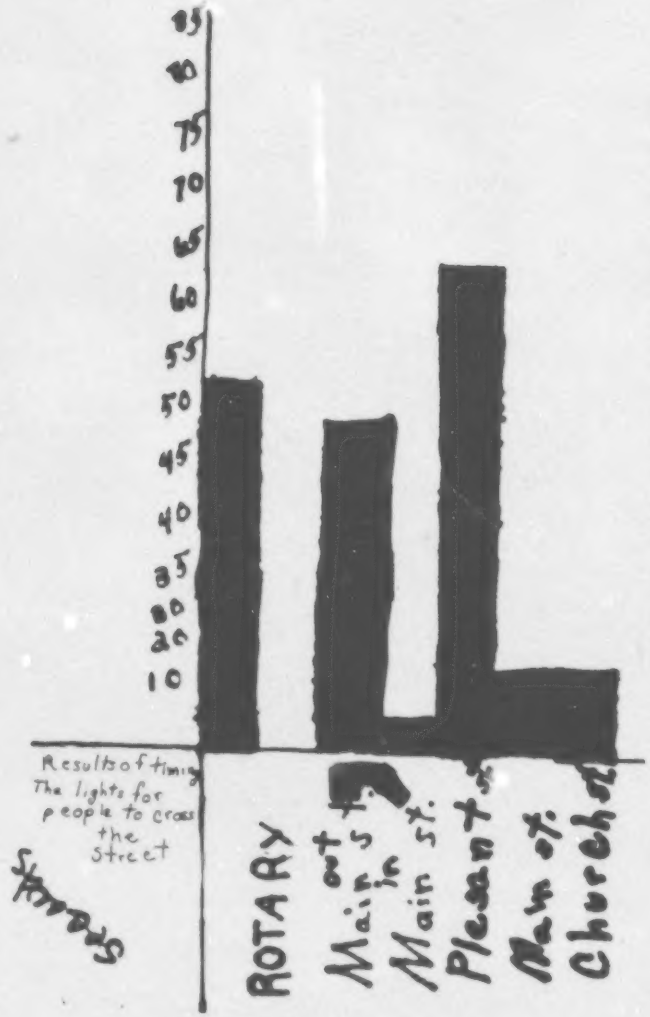
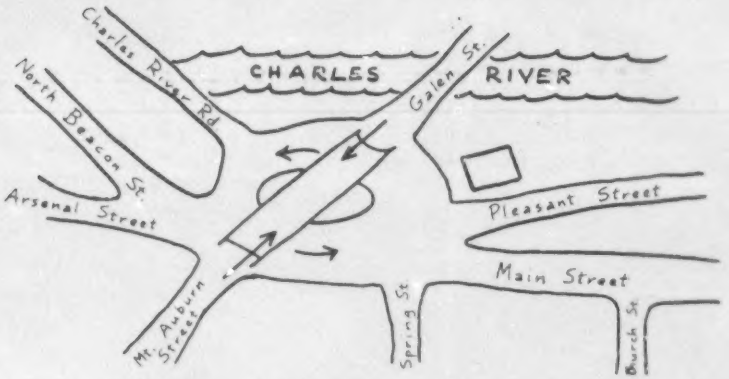
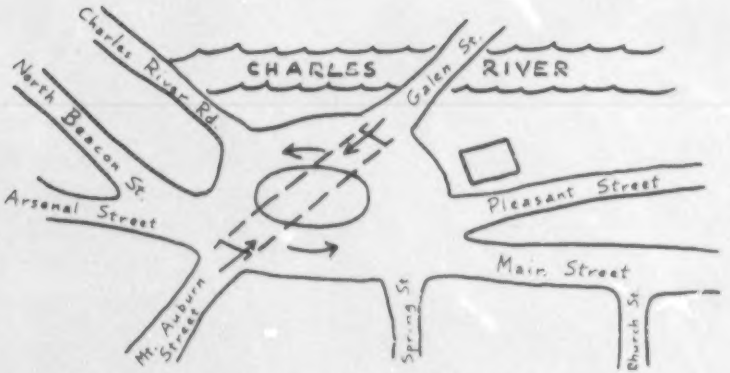


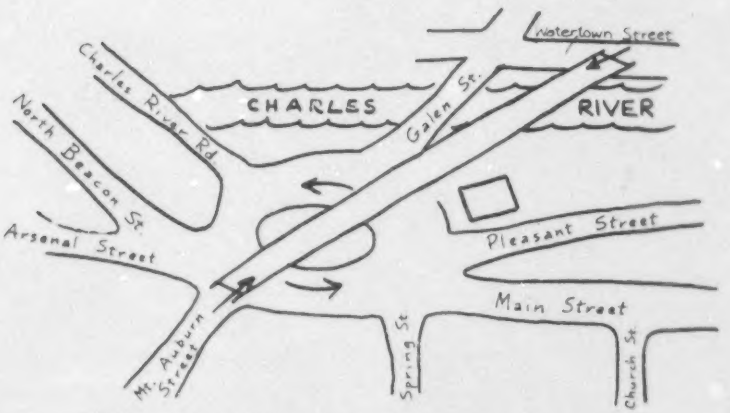
Figure C1-7



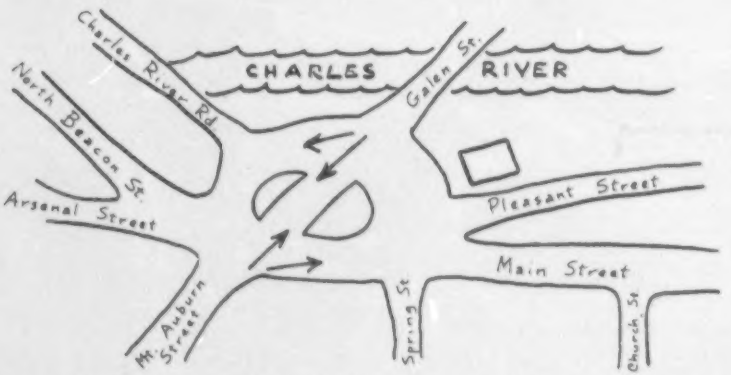
Overpass – Mt. Auburn St. to Galen St.



Tunnel – Mt. Auburn St. to Galen St.



Overpass – Mt. Auburn St. to Watertown St.



Street through island – Mt. Auburn St. to Galen St.

Figure C1-8

2. LOG ON TRAFFIC FLOW

by Bernard Walsh*
Hardy School, Grade 5
Arlington, Massachusetts
(September 1972-June 1973)

ABSTRACT

Students in this fifth-grade class responded to the Traffic Flow challenge by focusing on a nearby highway and traffic circle (rotary) where many accidents involving both cars and pedestrians, including a student fatality, had occurred. The class decided that road design at the rotary and lack of a pedestrian crossing were the main traffic problems to be solved. They first gathered information by taking pictures of the area and studying the photographs to see where the problems lay. Discussing the photographs, the children questioned whether many cars were not going faster than the posted speed limit and decided to measure the speed of the cars. After much confusion they figured out how to station themselves so that they could measure both the time (using a stopwatch) and the distance the cars travelled in five seconds. Other groups constructed models in the Design Lab for studying the highway as it existed and as they would like to improve it. After the teacher introduced the concept of traffic volume, the "tally" group concentrated on counting numbers of cars on the highway at different times of day. During the entire study, another group conducted interviews with government officials and certain local people to document other opinions on the traffic problems and on possible solutions. The class received blueprints of proposed changes from the State Department of Public Works and compared these to their own recommendations. They found that the State had planned a pedestrian overpass for the highway which corresponded with their findings. The children also proposed, in a final model, a bypass of the rotary for traffic going into Boston.

We began working on Traffic Flow during a class discussion about the traffic problems we had encountered in the vicinity of the school. We talked about the local streets in terms of whether or not they would be safe for riding bicycles, and the children mentioned two areas--Route 2 and Arlington Center--that they felt were unsafe.

*Edited by USMES staff

The children were particularly concerned about Route 2. They felt the highway presented some serious traffic hazards; the previous year, a child had been struck and killed there. Students related their personal reactions to the incident. We discussed the actions that had been taken and to make the road safer for the children who had to cross it: the addition of a dividing fence and the circulation of a petition for pedestrian safety. The class also discussed problems from the drivers' point of view, and the children decided that we might be able to improve the situation.

First, we listed problems created by the highway, including--

1. Speeding cars
2. Four lanes of traffic merging to two lanes approaching the rotary at the end of Route 2.
3. No pedestrian crossing--motorists had to slow down to avoid hitting the children
4. Numbers of accidents to both pedestrians and cars
5. Poor lighting in the area

Next, the class listed ways of collecting information on the problem:

1. Take pictures of problems we see
2. Interview people who live or work in the area to see what they can recall from past experience
3. Go to police or registry to get facts on the numbers of accidents
4. Have children observe the area regularly
5. Try to judge the speed of cars in the area
6. Try to construct a model of a pedestrian crossing
7. Try to get parents to help find a solution to the problem after we collect accurate facts

We planned a field trip to Route 2. The children decided to take along a camera for photographing the traffic problems. A camera committee, formed for this purpose, spent time learning how to operate their Polaroid camera. The rest of the class took notes on the traffic problems they observed around Route 2. After the field trip the children compared their observations with the pictures taken by the camera committee. The camera work helped the children understand the flow of traffic, particularly the design of the rotary and the lane changes.

The committee had taken seven pictures. During the next

class session, the children compiled a list of the traffic problems that they were able to spot in the photographs. The children then compared their list with the original list of problems. Three of the problems first cited by the students were included in the list of four problems observed in the photos (they are asterisked):

*1. No traffic lights for pedestrians
*2. Unmarked lanes where four lanes become two
*3. No crosswalks for people
4. No sidewalks.

The camera committee planned a second field trip during the next class session. The children decided to have each child in the group take two pictures, concentrating on the following places:

1. The speed limit signs on the road where Route 2 approaches the rotary
2. The changes from two lanes to the rotary and the narrow bridge
3. The intersection of Route 2 with Routes 3 and 16 at the rotary
4. The general flow of traffic at the bridge and the rotary
5. The motorists' problems with the approaches to Route 2.

During the field trip, they observed the speed of cars along Route 2 and noticed that they were moving too fast for pedestrians to cross safely. The committee decided that a group should be formed to collect data on speeds of vehicles and to verify them with the police department. The children discussed how speed could be measured and what instruments we would need. I introduced the children to the "How To" Cards on how to use a stopwatch and how to take tallies.*

During the next class session, the class was broken into two groups:

1. Measurement of Speed Group--spent the session familiarizing themselves with the stopwatch.

*The set of cards on "How to Find the Speed of Cars" was not available at that time--ED.

2. Camera Group--spent the session comparing the two sets of pictures that had been taken on the two field trips, then chose the ones that showed the most information.

I assured the children that we would rotate the groups throughout the year so that everyone would be familiar with the different group procedures.

Before going out in the field, the Measurement Group took turns practicing timing with a stopwatch. They timed various daily activities, including--

- How long it took me to walk from one point to another
- Time spent going to certain classes
- Time spent doing homework
- Time taken to eat lunch

The stopwatch was the only instrument that the children took with them on their first field trip. When the group arrived at Route 2, they discovered that the speed limit sign they had planned to use as a marker was missing. A discussion followed to decide what to do. Some children still wanted to time cars that were going by, but they soon realized that this would not be possible because they had yet to take an exact measurement of the distance from the starting point to the "finish line." The group listed the ways that they might get the necessary measurement on the next trip. These included--

1. Use a ruler and measure the distance from the end of the bridge (where the sign saying 25 mph had been) to the post

2. Use a tape measure to get the distance

3. Use their feet, noting that they would have to get a pair of size twelve shoes in order to have a one-foot standard

4. Use a measured or marked stick along the edge of the road

5. Measure the exact distance from one point to another by some measurement system that could be made up in the classroom

The children then sat by the road to develop a method of timing cars. They decided to station one of the boys as a fixed point with a stopwatch to record times of the cars that went from the starting point to his poisiton. The students realized that it would be impossible to time every car. Deciding to time only certain ones, they finally chose Volkswagens. The children also recognized the importance of consistence in their timings. Cars had to be timed from the same point in order to be sure of accurate measurements. It was decided that the person at the startting point would measure from the front of the car and not from the middle or rear. The person at the finish line would measure the time when the back of the car passed his location.*

The method the children planned to use worked like this. A person stationed at the rotary would raise a book in the air to indicate to the boy at the starting point that the Volkswagen had passed. The timer at the starting point would record the time when the car reached his point, ignoring any other Volkswagen that came through until the car had passed the finish line. The timer at the finish line would record the time for the car to pass that point.

The children tried this method on ten cars. After the data were collected, the group returned to the school and presented their information to the rest of the class. The timing data, sketch, and some figuring is shown in Figure C2-1.

During the next class discussion we talked about what type of measuring device would be most accurate for determining the distance over which the cars were to be timed. The class listened to the reports of the measuring group and made the decision to use either a 100-foot tape measure or a measured string to determine the distance from the rotary to the starting point. When the children went out to measure the area, they found the distance to be 300 feet.

Besides the confusion over having to be aware of two factors, time and distance, the children encountered other problems while measuring speed. The Measurement Group reported the problems they had encountered in the field:

1. Not being able to start the stopwatch on time

2. Confusion as to which car was being timed

*The measurements would be more accurate if they consistently used the front of the car.--ED.

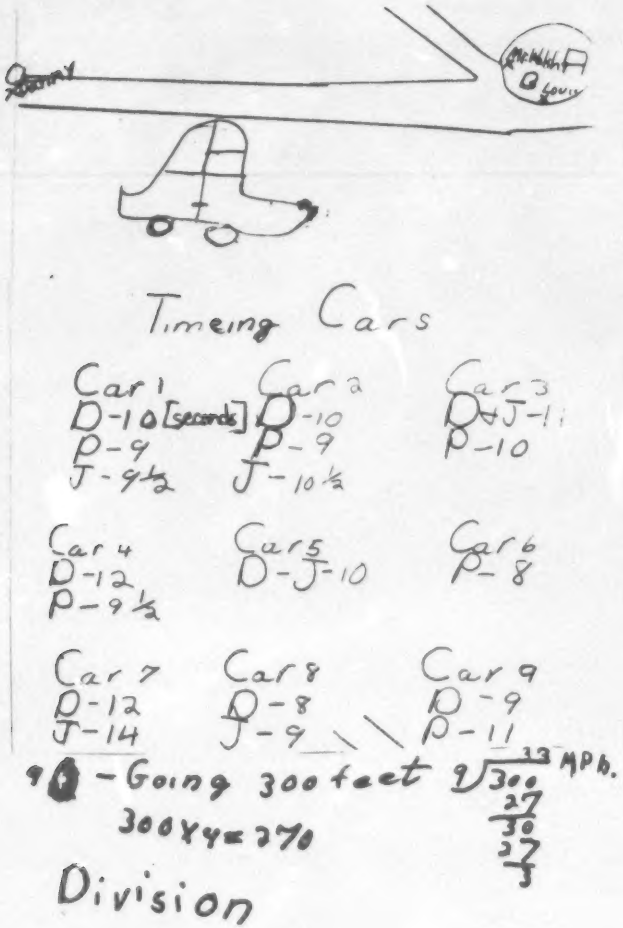
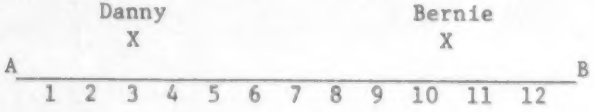


Figure C2-1

3. Impaired vision, which made it impossible to determine when the timed car reached the finish line

They also had trouble with the math involved in determining speed. The children were confused about what process to use--distance + time (addition), distance - time (subtraction), distance x time (multiplication), or distance/time (division).*

When the Design Lab opened in October, the children in the Measurement Group worked on a simulation activity with a marble that they hoped would help them work out a method of determining speed. During our first simulation session, six children placed a piece of masking tape on the door. A tape measure was stretched next to the tape for a distance of twelve feet and the tape was marked off at one-foot intervals. Most of the children were situated at Point A, the beginning of the "roadway." Their responsibility was to release a marble along the track after a countdown. Two children with stopwatches at Point B, the end point, timed the marble for two seconds. Another child and myself were stationed at points along the measure tape; we were expected either to stop the marble or to note its position after two seconds. A diagram of the model and the results of ten trials are shown below.



Distance Covered in Two Seconds

Test 1 -	7' 6"	Test 6 -	9' 4"
Test 2 -	9' 9"	Test 7 -	4' 5"
Test 3 -	No measurement Too fast on road	Test 8 -	6' 4"
Test 4 -	5' 9"	Test 9 -	6' 5"
Test 5 -	10' 9"	Test 10-	11' 0"

*As a result of discussions with members of the USMES staff, "How to Find the Speed of Cars" and "How to Find How Many Feet Per Second is the Same Speed as 60 Miles Per Hour" were written for children.

The children identified the variables affecting speed as the speed at which the marble was released and whether or not the marble touched the side of the course.

During the next session, the group constructed a roadway model using small pieces of wooden dowels for the sides. From their simulation experiments with this model, the children felt that two major problems emerged:

1. How to control the marble speed

2. How to keep the marble from bumping the sides of the track

The model helped the children in the Measurement Group understand some of the factors involved in measuring speed. They were still concerned, however, about not being able to understand the calculations. Although some children in the group were now convinced that speed was determined by dividing distance by time, the problem of conversion from feet per second to miles per hour was still unsolved.

To help the children overcome the math problem, I asked the Measurement Group to present the problem of determining the speed of a car to the entire class. During the next sessions, the group presented their data and a report of the group activities to the class. They informed the other children about their trial tests with a marble and about the math problems they had done so far.

Since the math involved in converting feet per second to miles per hour seemed too difficult for the children, I introduced the concept of the conversion graph to the children. Playing games such as "Battleship", "Tic-Tac-Toe", and "Blind Man Sink" provided opportunities for the children to plot points on a graph. When the whole class began to work on these activities along with the Measurement Group, we made progress. As a class, we worked out the calculation that sixty miles per hour is equal to eighty-eight feet per second. Groups of children then made conversion graphs and practiced changing car speeds in feet per second to miles per hour.

When the entire class had worked on these activities, the Measurement Group planned another field trip to Route 2 to collect data on speed of cars. They decided that they would find speed by measuring the distance Volkswagens traveled in five seconds. Taking along stopwatches and a fifty-foot tape measure, we went back to the location where we had collected data in September. Two children with a stopwatch were stationed at the starting point, a 25 mph

speed limit sign. One child operated the stopwatch while the other signaled to indicate that the timing had begun. Two other children situated between the starting point and the selected ending point kept their stopwatch going for five seconds and signaled when the timing had ended.* A third group of children observed and marked the position of the car when the timing had ended. The children timed and marked the distance that each of five Volkswagens traveled in five seconds. After all the timings had been completed, the children measured the distance covered by each car. Then they calculated the speed of the vehicles during the next class session. Their data and calculated speeds are shown below.

Speeds of Volkswagens on Route 2

Car 1 - 199' in 5 seconds -- 40' per second
Car 2 - 231' in 5 seconds -- 46' per second
Car 3 - 241' in 5 seconds -- 48' per second
Car 4 - 237' in 5 seconds -- 47' per second
Car 5 - 243' in 5 seconds -- 49' per second

The children used conversion graphs to change their data recorded in feet and seconds to speed in miles per hour. They were very concerned that their measurements were not precise. A class discussion followed on approximation and rounding off numbers. It was hard for the children to accept the idea that exact answers were not only not always needed but sometimes impossible to determine. We explored the use of estimation and how it was necessary in our methods of data collection. The following chart shows the children's conversions of feet per second to miles per hour.

Conversion of Feet Per Second to Miles Per Hour

Car #	Feet Per Second	Miles Per Hour
Car 1	40' per second	27 mph
Car 2	46' per second	31 mph
Car 3	48' per second	33 mph
Car 4	47' per second	32 mph
Car 5	49' per second	34 mph

*It is not clear why the students used two stopwatches. Using one stopwatch and a good hand signaling system might be easier.--ED.

During work on the Traffic Flow challenge the Design Lab provided an important focus for unit activities. Those children previously uninvolved in the unit became interested in building models of roadways and constructing trundle wheels. Besides the Measurement Group's simulation activities with the marble, four other projects were worked on by the class during the course of the unit. Each group was asked to plan its project, draw a sketch, present it to the class, and begin work on its design.

Group 1 -- build a model roadway in order to test the speed of model cars using data from the Measurement Group

Group 2 -- build a model of Route 2 the way it is now and indicate areas where most of the accidents occur as well as how they happen

Group 3 -- construct a trundle wheel to be used in measuring distances on Route 2

Group 4 -- construct a model of Route 2 the way it should appear (with an overpass, overhead lights, etc.)

Figure C2-2 is a student sketch of the way Route 2 looks presently, while Figure C2-3 shows one child's plan for Route 2 in the future.

Four children working on testing model cars on an inclined roadway set up a piece of plywood as a track. The children were puzzled because the cars kept falling off the track when they tested them. I presented the children with some questions to think over before the next session.

1. Why were the cars falling off the road?

2. How was the model car built?

3. What was the road made of? How did it feel?

4. Does the surface of the road affect the speed of a car?

5. What about other materials for the road? What would you choose and how would it cut down on friction?

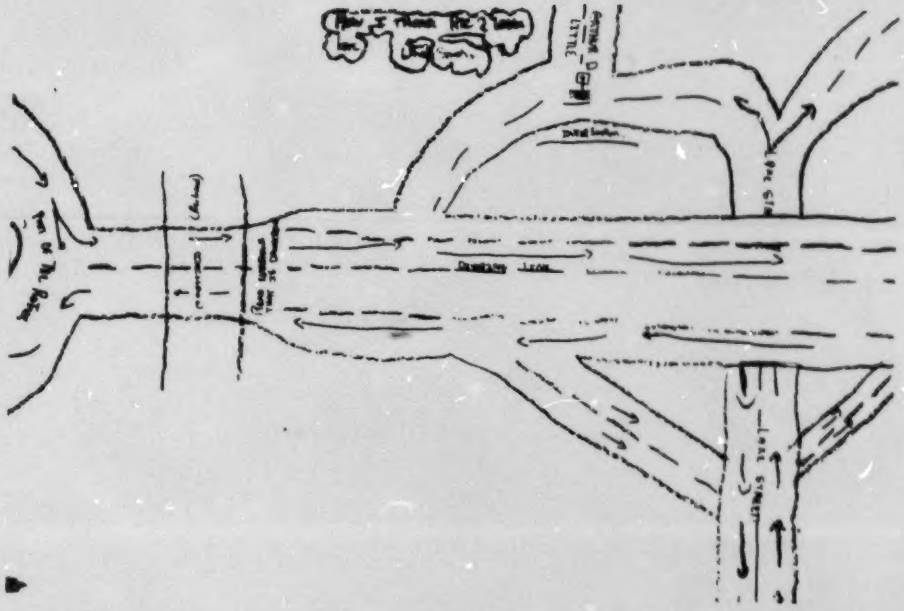
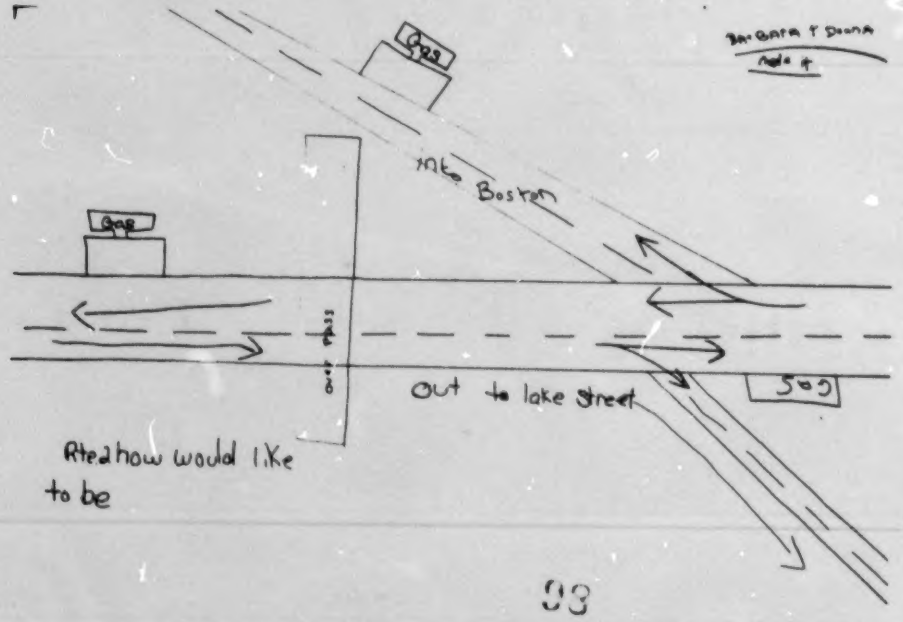
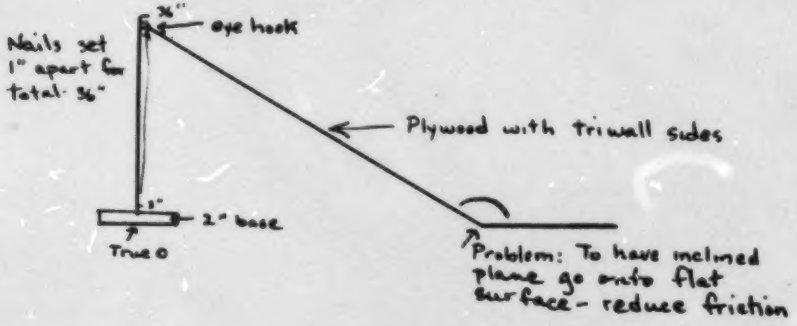


Figure C2-2


Take Boston
out to lake Street
Rte 1
Rte 1
Rte 1

The children in this group spent the next several sessions in the Design Lab trying to work out the solutions to these questions. They finally chose a piece of plywood that was long enough not to bend under the weight of the cars as they went down. To find out how speed of an object is affected by different heights, they needed to make the angle of the incline adjustable. Part of the group calibrated a piece of lumber for thirty-six inches and mounted the wood on a base. Each inch of height was marked by a nail. The track was attached to the nails with a screweye so that the height could be adjusted. In order to keep the model on the track, several students attached Tri-Wall strips to the sides. Here is a sketch of their model:


36"
eye hook
Nails set 1" apart for total 36"
Plywood with triwall sides
2" base
True 0
Problem: To have inclined plane go onto flat surface - reduce friction

During successive sessions the children ran trial tests of their model on the inclined roadway. The children solved various problems as they arose. For instance, the car wheels had to be adjusted because they seemed to tighten as they moved down the track. They also tried using a Tri-Wall incline because the plywood seemed to make the cars veer to the side. Over several weeks of observation, however, the children were able to make this conclusion: the greater the incline of the surface, the faster the speed of the moving object at the bottom of the hill.

While the various groups worked on models in the Design Lab, the Measurement Group and I decided to count cars at various points along Route 2 so that we would know where and when traffic was heaviest. Before going out on our field trip, we examined "How To" Cards on tallies and bar graphs and practiced making bar graph tallies. The entire class was involved in a discussion of the activities of the

new Tally Group.

Using a model constructed by the children at the USMES Winter Workshop, I introduced the concept of traffic volume to the class. After we had discussed the term, I asked how the volume of traffic related to the size of the roadway. The children responded that a small road would have trouble handling a large number of cars--for example, Chandler Street near the school. The children compared what Route 2 would look like at the rush hour to its appearance when we had observed it in early afternoon. The class felt that the volume of cars would be greater at rush hour, causing more problems.* A discussion then followed as to important times to collect more traffic data.

TEACHER: We're interested in going back to Route 2, but at what particular time?
STUDENT: In the morning?
TEACHER: Why?
STUDENT: Because that's when everybody's going to work.
TEACHER: We want to go at what particular time then?
STUDENT: The rush hour.
TEACHER: What might we see at rush hour that we would not have seen before?
STUDENT: A lot of cars.

The class decided to measure the volume of traffic on the road at rush hour for a half hour. Our final activity before our field trip was to pinpoint problem areas at which to station observers. These were the following locations:

Point A - rotary

Point B - half way around the rotary

Point C - narrow bridge

Point D - four lanes into two lanes

During the next session the Tally Group went to the rotary to count cars during rush hour. We arrived at the bridge at 8:50 A.M. and stationed ourselves at the 25 mph sign to conduct our tally and make our observations. The children observed that--

*The density of cars at rush hour might be greater, but if there is a traffic jam, the traffic volume could actually be less than at other times of day since the cars would be moving more slowly. See Glossary for definitions of traffic volume and traffic density.--ED.

1. Traffic was very heavy.

2. Traffic was backed up to the bridge away from the rotary.

3. Traffic could not move at the posted 25 mph speed limit.

4. Cars were moving very slowly at all points.

5. Greatest problem was at Point C where traffic is half-way around the rotary.

The group made three tallies beginning at 8:55 A.M.

Trial #1 (8:55) Cars counted for one minute
42 cars (other children had same count for same period)

Trial #2 (9:00) Cars counted for one minute
43 cars (cars had been released from traffic jam up the road)

Trial #3 (9:05) Cars counted for two minutes
68 cars

The children made the following observations at 9:10 A.M.

1. Traffic not as heavy as when we arrived

2. Traffic moving around rotary with more ease

3. Point C still a problem

4. Cars going faster; probably exceeding the 25 mph limit

A final tally was made by the children at 9:23 A.M.

Trial #4 (9:23) Cars counted for three minutes
109 cars (more often, fewer problems)

An example of a data sheet from the Tally Group's observations may be found in Figure C2-4.*

*The children might construct a scatter graph of the volume (number of cars per minute) vs. the time of day.--ED.

Tally Group Observation of Rte 2 Rush Hour

8:55 cars going 5 miles per hour

Heavy Traffic volume 8:55 Tuesday April 9, 1979

No 1 8:55 1 minute 42 cars. Point D
No 2 9:00 1 minute 43 cars. Point D
No 3. 9:05 2 minutes 68 cars. Point D
Cars not going as slow as 8:55
No 4 9:23 3 minutes 109 cars Point D

Figure C2-4

Children in the Tally Group reported to the rest of the class during the next session. The class was concerned about the amount of congestion at various points as well as the total number of cars. They noted that as nine o'clock passed, the volume of traffic decreased. As the volume decreased, the speeds of cars increased, and much skidding occurred when cars braked because of sudden traffic jams. The children inferred from the data presented that traffic thinned out and the problems decreased as the morning went on.

During the first field trip the class had taken to Route 2, the children had met a man who owned a gas station along the road. He had described some of the problems as he saw them from his location. The children who had talked to him were very excited about having conducted an interview and were anxious to form an interview committee to gather more information from other people. This group of students conducted interviews with members of the community, town government, and the Department of Public Works throughout the entire study. Information gathered in later interviews proved helpful in reexamining our own proposals and designs for changes.

Materials used for interviewing included a tape recorder, note paper, pencil, and sometimes videotape equipment. Here are some questions the students asked:

1. What kind of problems do you see in the area when you come to work?

2. What do you think some of the dangers are in the area for the children?

3. Do you think the speed limit should be lowered?...To what?

4. Do you think the guardrail helps? If not, why?

5. Do you think Route 2 is better now than a year ago? If not, why?

6. What do you think about the rotary at the end of Route 2? What would you put in place of it?

7. Do you think we should have sidewalks on Route 2?

The children interviewed many people in different official positions. Here is a list summarizing the information gained from these interviews as well as from their first interview with the garage owner.

Position	Knowledge/Direction Gained From Interview
Executive at Arthur D. Little	Need for overhead lighting; role of politics in problems of road, e.g., the type of fence recommended to the state not constructed; need for safety education of children.
Garage Owner	Speed as safety factor; need for overhead lights; danger to children; difficulty getting road improved.
Town Meeting Members	Need for overhead crosswalk; need for better lighting; need for improvement to rotary; information on how to get recognition on floor of town meeting; children directed to state to get necessary answers; stressed children's models.
Asst. Town Manager	Recommendation of town government, overhead lights, sent to Department of Public Works--no action; no immediate cost to taxpayers of Arlington.
Public Safety	Route 2 comes under jurisdiction of five police departments.
Department of Public Works	State proposed changes: pedestrian crossing in planning stage. Received blueprints of proposed changes.

Toward the end of the school year, the class began a survey of teachers, students, and parents to gather additional opinions on the traffic problems created by Route 2. They hoped to be able to compare other people's perceptions of the traffic problems with the quantitative data they had collected along the roadway. However, there was not enough time left for them to complete this activity before the year ended.

When the children conducted an interview with a representative of the Massachusetts Department of Public Works, they were given a set of blueprints of the changes for

Route 2 proposed by the state. The children compared the blueprints with designs made by the group building a model of Route 2 as they would like it to look. They first noted that the blueprints were much more exact than their own diagrams. Their examination of the state's diagrams showed that the following changes were being considered:

1. A portable pedestrian overpass (to be constructed first)

2. Installation of street lights

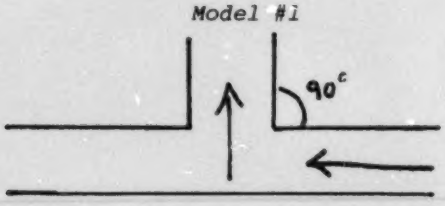
3. Construction of gravel and concrete sidewalks

4. Warning signs to cars entering the rotary

We also discussed the angle of entrance of roads coming into Route 2 from businesses along the highway. The blueprints indicated that the state was planning ninety-degree angles for these entrances, as opposed to the forty-five degree angle used for most super highways. We agreed that in this case, entering on a right angle would be safer because drivers would be forced to stop and look, rather than merging into the traffic from an acute angle.

Following this discussion, the children working on the model of the "future Route 2" began constructing an exit ramp leading from the main road to the other side at a ninety-degree angle. I realized that they were confusing the entrances recommended by the state with the exit ramp. We spent several sessions discussing angles of exit and entry to a road. The children were confused by the lessons, and we had to backtrack and try a different approach.

During the next session, the following diagram of the group's proposed ramp was drawn on the board:



I asked the children to consider these questions concerning the flow of traffic in their design:

1. What would happen to the traffic that tried to exit from the road at this angle if cars were going at 60 mph?

2. What effect does the speed of a moving object have on objects that are in its path?

3. What would the area of collision be on your model?

4. Can you design another model, keeping in mind the angle of exit off the road?

To help the children understand the relationship of their model to the real world, we tried simulation exercises using children as cars and doorways to represent exits from the highway. We decided to have different "cars" try different angles of exit from the aisle to the corridor so that the children would understand the relationship between speed and angle of exit. First, a boy pretended to be an automobile traveling at 60 mph approaching the ramp. The boy raced down the aisle and made a sharp right turn out the door. He repeated this action several times, each time at a faster rate. The last time he nearly collided with the door frame.

The children discussed their observations of the simulations and established the following conclusions:

1. An object moving down a roadway stays on the outside edge of the curve.

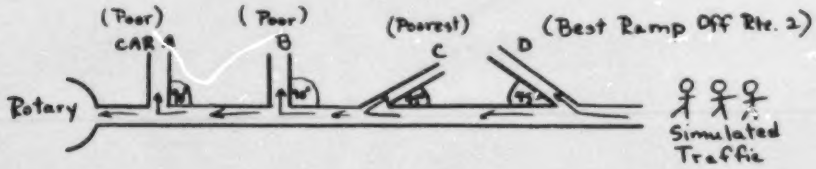
2. In a two lane road, a car on the inside lane approaching a curve at a fast, steady speed will be drawn to the outside lane, possibly causing an accident.

3. The angle of the road leading off a super highway makes a difference.

4. A gradual reduction of speed in addition to the proper angle of exit reduces the chances of collision.

More complex simulation activities continued as the

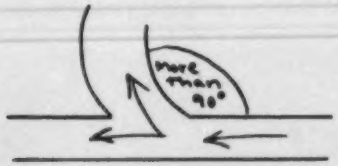
children drew different types of exit ramps of Route 2 with chalk on the floor and tested the various angles. Here is a sketch of one of their diagrams from the simulation activities:



They concluded that Exit D, as shown above, was the best type of exit ramp for their purpose.

When the class had completed simulation activities, the children in the "future Route 2" group reconstructed their exit ramp to look like the ramp in the sketch below:

Model #2



When the final model had been completed, the group presented it to the rest of the class. The children compared it to the neat blueprints of the Massachusetts Department of Public Works and decided that it was still fairly rough, but they were pleased with the results. (See sketch at top of next page).

The following year the pedestrian overpass shown in the photograph was erected. This was consistent with (though not a direct result of) the children's recommendations.

Sketch of final model, Route 2, with proposed exit ramp for traffic.

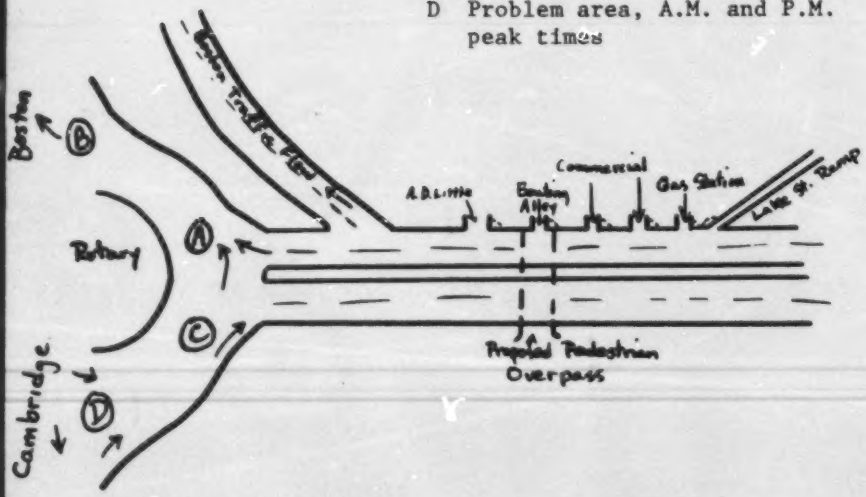
Points

A Major traffic problem area--most prime collision area (A.M. traffic flow)

B Collision area--traffic snarl

C Secondary collision area (prime area, P.M. traffic flow)

D Problem area, A.M. and P.M. peak times



Ramp was supported by stilts.

Problems during construction:

1. Angle of exit was initially too sharp
2. Speed of moving cars had to be considered

Ramp Allows:

1. Free flow of traffic to Boston away from rotary
2. Present road at rotary to be used as one-way from Boston and for local traffic

D. References

1. LIST OF "HOW TO" CARDS

Below are listed the current "How To" Card titles that students working on the Traffic Flow challenge might find useful. A complete listing of both the "How To" Cards and the Design Lab "How To" Cards is contained in the USMES Guide. In addition, the Design Lab Manual contains the list of Design Lab "How To" Cards.

GEOMETRY

- G 3 - How to Construct a Circle Which is a Certain Distance Around

GRAPHING

- GR 1 - How to Make a Bar Graph Picture of Your Data
- GR 2 - How to Show the Differences in Many Measurements or Counts of the Same Thing by Making a Histogram
- GR 3 - How to Make a Line Graph Picture of Your Data
- GR 4 - How to Decide Whether to Make a Bar Graph Picture or a Line Graph Picture of Your Data
- GR 5 - How to Find Out If There is Any Relationship Between Two Things by Making a Scatter Graph
- GR 6 - How to Make Predictions by Using a Scatter Graph
- GR 7 - How to Show Several Sets of Data on One Graph

MEASUREMENT

- M 1 - How to Use a Stopwatch
- M 2 - How to Measure Distances
- M 3 - How to Measure Large Distances by Using a Trundle Wheel
- M 6 - How to Find the Speed of a Car
- M 7 - How to Find How Many Feet per Second is the Same Speed as 60 Miles per Hour
- M 9 - How to Make a Conversion Graph to Use in Changing Measurements from One Unit to Another Unit
- M 10 - How to Use a Conversion Graph to Change *Any* Measurement in One Unit to Another Unit

PROBABILITY AND STATISTICS

- PS 2 - How to Record Data by Tallying
- PS 3 - How to Describe Your Set of Data by Finding the Average
- PS 4 - How to Describe Your Set of Data by Using the Middle Piece (Median)
- PS 5 - How to Find the Median of a Set of Data from a Histogram

RATIOS, PROPORTIONS, AND SCALING

R 2 - How to Make a Drawing to Scale
R 3 - How to Make Scale Drawings Bigger or Smaller

New titles to be added in 1976:

How to Round Off Data
How to Compare Two Sets of Data by Making a Q-Q Graph
How to Design and Analyze a Survey
How to Choose a Sample
How to Compare Two Sets of Data by Using Interquartile Ranges
How to Make and Use a Cumulative Distribution Graph

A cartoon-style set of "How To" Cards for primary grades is being developed from the present complete set. In most cases titles are different and contents have been rearranged among the various titles. It is planned that this additional set will be available early in 1977.

2. LIST OF BACKGROUND PAPERS

As students work on USMES challenges, teachers may need background information that is not readily accessible elsewhere. The Background Papers fulfill this need and often include descriptions of activities and investigations that students might carry out.

On the following pages are resumes of Background Papers that teachers may find pertinent to Traffic Flow. The papers are grouped in the categories shown, but in some cases the categories overlap. For example, some papers that deal with graphing also include probability and statistics.

DESIGN PROBLEMS

DP 7 Traffic Congestion by James Kneafsey
DP 8 Traffic Flow at Pedestrian Crossings by James Kneafsey
DP 9 Traffic Flow under Alternative Structural Conditions by James Kneafsey
DP10 The Need for Traffic Signal Synchronization in Urban Areas by James Kneafsey
DP11 The Impact of Parking Restrictions on Traffic Flow in Urban Areas during Peak Periods by James Kneafsey
DP12 Traffic Flow at Rotaries by James Kneafsey
DP14 Speed, Travel Time, Volume, and Density Relationships in Traffic Flow (based on suggestions by James Kneafsey)

GROUP DYNAMICS

GD 2 A Voting Procedure Comparison That May Arise in USMES Activities by Earle Lomon

GRAPHING

GR 2 Notes on Data Handling by Percy Pierre
GR 3 Using Graphs to Understand Data by Earle Lomon
GR 4 Representing Several Sets of Data on One Graph by Betty Beck
GR 6 Using Scatter Graphs to Spot Trends by Earle Lomon

MEASUREMENT

M 2 Measuring Heights of Trees and Buildings by Earle Lomon
M 3 Determining the Best Instrument to Use for a Certain Measurement by USMES Staff
M 4 Measuring the Speed of Cars by Earle Lomon
M 5 Electric Trundle Wheel by Charles Donahoe

PROBABILITY AND STATISTICS	*PS 4 Design of Surveys and Samples* by Susan J. Devlin and Anne E. Freeny
	PS 5 Examining One and Two Sets of Data Part I: A General Strategy and One-Sample Methods by Lorraine Denby and James Landwehr
	PS 6 Examining One and Two Sets of Data Part II: A Graphical Method for Comparing Two Samples by Lorraine Denby and James Landwehr
RATIOS, PROPORTIONS, AND SCALING	*R 3 Making and Using a Scale Drawing* by Earle Lomon
SIMULATION ACTIVITIES	*SA 4 Simulation/Modeling as a Tool in Assessing Various Solutions* by Betty Beck

3. BIBLIOGRAPHY OF NON-USMES MATERIALS

The following references on traffic and road design may be of some use in teaching Traffic Flow. A list of references on general mathematics and scientific topics can be found in the USMES Guide.

Baerwald, John. E., ed. *Traffic Engineering Handbook*. 3rd ed. Washington, D.C.: Institute of Traffic Engineers, 1965.

A technical guide to traffic in the U.S., including chapters on traffic characteristics, survey methods, and urban planning. Section on geometry of roadways discusses various criteria to consider when evaluating intersection and street design.

Charles Eliot Junior High School Ecology Club, *Eyeballing Traffic Flow: An Environmental Awareness Study*. Cleveland, Ohio: Institute for Environmental Education, 1973.

Short paper on measuring traffic flow at various times of the day by counting cars at an intersection. Useful for both teachers and students.

Matson, Theodore *et al*. *Traffic Engineering*. New York McGraw Hill, 1955.

A guide for traffic engineers of traffic flow characteristics and administrative procedures. Contains sections on control devices, intersection design, and planning for traffic flow.

Maps and aerial photographs showing traffic flow patterns may be obtained from state government agencies (e.g., Massachusetts Department of Public Works) or traffic engineering departments at a city or university.

A list of available government publications concerning traffic flow may be obtained by writing to the Superintendent of Documents, Washington, D.C.

4. GLOSSARY

The following definitions may be helpful to a teacher whose class is investigating a Traffic Flow challenge. Some of the words are included to give the teacher an understanding of technical terms; others are included because they are commonly used throughout the resource book.

These terms may be used when they are appropriate for the children's work. For example, a teacher may tell the children that when they conduct surveys, they are collecting *data*. It is not necessary for the teacher or students to learn the definitions nor to use all of the terms while working on their challenge. Rather, the children will begin to use the words and understand the meanings as they become involved in their investigations.

Average	The numerical value obtained by dividing the sum of the elements of a set of data by the number of elements in that set. Also called the mean.
Brake Distance	The distance a vehicle (e.g., bicycle, car) travels from the time the brakes are applied to the time it stops.
Calibration	Setting and marking an instrument to correspond to standard measurements.
Centripetal Force	An inward force on an object that causes it to move in a curved path. For example, when a car goes around a curve the road exerts a force on the tires that causes the car to go in a curved path.
Congestion	A traffic flow problem that exists when the volume or density of traffic affects average speed to the point where normal traffic flow is reduced sharply.
Conversion	A change from one form to another. Generally associated in mathematics and science with the change from one unit of measure to another or the change from one form of energy to another.
Correlation	A relationship between two sets of data.
Cost	The amount of money needed to produce or to purchase goods or services.
Data	Any facts, quantitative information, or statistics.

Degree — A unit of measurement of temperature or angle.

Density — See *Traffic*.

Distribution — The spread of data over the range of possible results.

Economics — A social science concerned chiefly with description and analysis of the production, distribution, and consumption of goods and services.

Event — A happening; an occurrence; something that takes place. Example: a car arriving at an intersection.

Force — A push or a pull.

Frequency — The number of times a certain event occurs in a given unit of time or in a given total number of events.

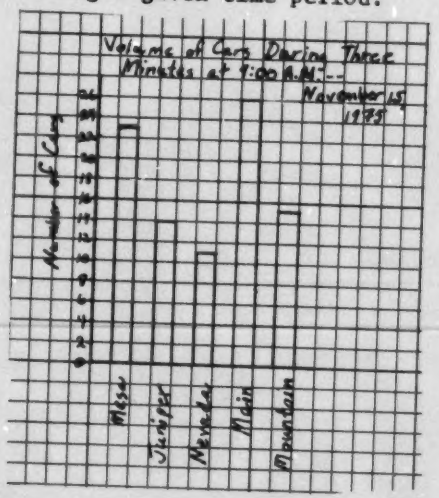
Friction, Sliding — A force between two rubbing surfaces that opposes their relative motion.

Gap Time — The time interval between successive arrival times of vehicles at an intersection.

Graph — A drawing or a picture of one or several sets of data.

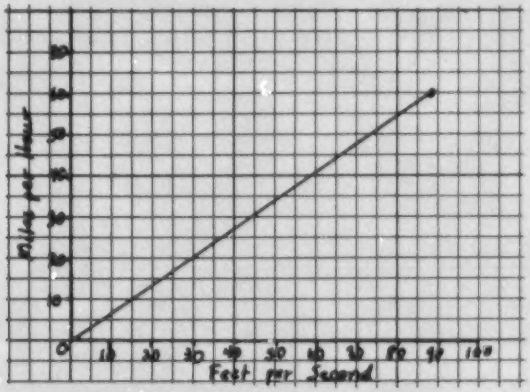
Bar Graph — A graph of a set of measures or counts whose sizes are represented by the vertical (or horizontal) lengths of bars of equal widths or lines. Example: volume of cars along several different streets during a given time period.

Street	No. of Cars
Mesa	23
Juniper	14
Nevada	11
Main	26
Mountain	15



Conversion Graph

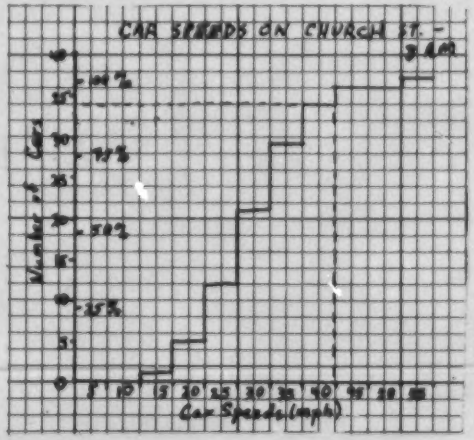
A line graph that is used to change one unit of measurement to another. For example, changing feet per second to miles per hour.



Cumulative Distribution Graph

A graph that can be constructed from a histogram by computing running totals from the histogram data. The first running total is the first value in the histogram data (see table of values). The second running total is the sum of the first and second values of the histogram; the third is the sum of the first, second, and third values, and so on. The horizontal scale on the graph is similar to that of the histogram; the vertical scale goes from zero to the total number of events observed or samples taken (in the example, the total number of cars for which speed measurements have been taken along a street). Each vertical distance on the graph shows the running total for the value shown on the horizontal scale; thus the graph below indicates that thirty-four cars have a speed of forty miles per hour or less.

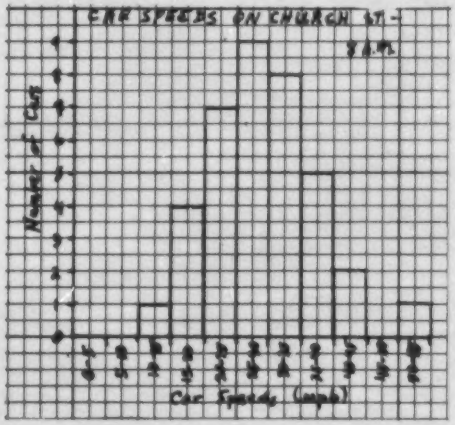
Car Speed (mph)	Running Totals
15 or less	1
20 " "	5
25 " "	12
30 " "	21
35 " "	29
40 " "	34
45 " "	36
55 " "	37



Histogram

A type of bar graph that shows the distribution of the number of times that different measures or counts of the same event have occurred. A histogram always shows numerical data on the horizontal axis. Example: the different number of cars traveling at different speeds along a street.

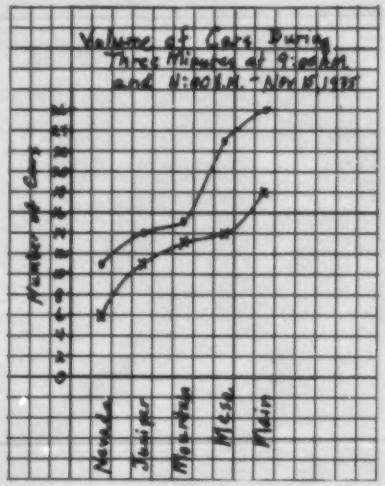
Number of Cars	Speed (mph)
1	10-15
4	15-20
7	20-25
9	25-30
8	30-35
5	35-40
2	40-45
1	50-55



Line Chart

A bar graph that is represented by circles, triangles, or crosses with lines connecting them so that it has the appearance of a line graph. (See *Line Graph*.) This is a useful representation when two or more sets of data are shown on the same graph. Example: the volume of cars along several different streets at different times of day.

Street	Number of Cars 9:00 A.M.	Number of Cars 11:00 A.M.
Nevada	11	6
Juniper	14	11
Mountain	15	13
Mesa	23	14
Main	26	18



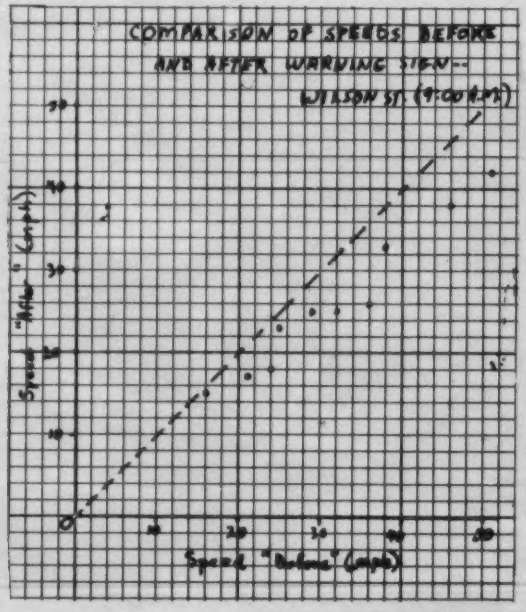
Line Graph

A graph in which a smooth line or line segments pass through or near points representing members of a set of data. Since the line represents an infinity of points, the variable on the horizontal axis must be continuous. If the spaces between markings on the horizontal axis have no meaning, then the graph is not a line graph but a line chart (see *Line Chart*), even if the data points are connected by lines.

Q-Q Graph

A graph that shows the comparison between the same type of data collected from two groups of people or from two different situations. Example: speeds of cars along a street before a warning sign has been posted and after a sign has been posted. The data for each set is ordered and the smallest measurement of one set plotted against the smallest of the other set, the second smallest against the second smallest, etc. The scatter of points is compared to a reference line, a dashed 45° line that represents data from two identical sets.

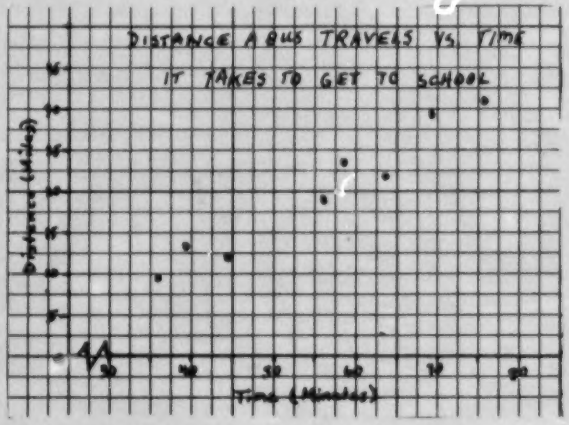
Car Speeds Before Warning (mph)	Car Speeds After Warning (mph)
16	15
21	17
24	18
25	23
29	25
32	25
36	26
38	33
46	38
51	42



Scatter Graph

A graph showing a scatter of points, each of which represents two characteristics of the same thing. For example, in the graph below, the position of each point indicates the time a bus takes to get to school vs. the distance it travels.

Time (Min.)	Distance (Mi.)
36	9
39	13
44	12
57	18
58	23
63	22
69	29
76	31



Histogram

See *Graph*.

Hypothesis

A tentative conclusion made in order to test its implications or consequences.

Inference

An assumption derived from facts or information considered to be valid and accurate.

Mean

See *Average*.

Median

The middle value of a set of data in which the elements have been ordered from smallest to largest. The median value has as many elements above it as below it.

Mode

The element or elements in a set of data that occur most often.

Momentum

The momentum of an object in the direction of its motion is the product of its mass and speed in the direction of its motion.

Negative	A transparent material upon which a photographic image has been formed; used for printing photographs.
Ordered Set	A set of data arranged from smallest to largest.
Per Cent	Literally, per hundred. A ratio in which the denominator is always 100, e.g., 72 per cent = 72/100 = 0.72 = 72% , where the symbol % represents 1/100.
Percentage	A part of a whole expressed in hundredths.
Population	Any group of objects (e.g., people, animals, items) or events from which samples are taken for statistical measurement.
Probability	The likelihood or chance (expressed numerically) of one event occurring out of several possible events.
Proportion	A statement of equality of two ratios, i.e., the first term divided by the second term equals the third term divided by the fourth term, e.g., 5/10 = 1/2. Also a synonym for ratio: when two quantities are in direct proportion, their ratios are the same.
Quartile	
First	The first quartile is the value of the quarter-way piece of data in an ordered set of data.
Third	The third quartile is the value of the three-quarter-way piece of data in an ordered set of data.
Interquartile Range	The range or length of the middle 50% of an ordered set of data; the difference between the first and third quartile.
Range	The difference between the smallest and the largest values in a set of data.
Rank	To order the members of a set according to some criterion, such as size or importance. Example: to put pieces of data from smallest to largest.
Ratio	The quotient of two denominate numbers or values indicating the relationship in quantity, size, or amount between two different things. For example, car speed is a ratio of the distance a car travels to the time it takes to cover this distance, such as $\frac{100 \text{ feet}}{3 \text{ seconds}}$.

Sample	A representative fraction of a population studied to gain information about the whole population.
Sample Size	The number of elements in a sample.
Scale	A direct proportion between two sets of dimensions (as between the dimensions in a drawing of an intersection and those of the actual intersection).
Scale Drawing	A drawing whose dimensions are in direct proportion to the object drawn.
Scale Map	A map whose dimensions are in direct proportion to the dimensions of the area represented.
Scale Model	A three-dimensional representation constructed to scale.
Sight Distance	The maximum distance from a given point at which a vehicle can be seen.
Speed	A measure of how fast something is moving. The distance covered divided by the elapsed time.
Statistics	The science of drawing conclusions or making predictions using a collection of quantitative data.
Tally	A visible record used to keep a count of some set of data, especially a record of the number of times one or more events occur. Example: number of cars passing a certain point in a given period of time.
Traffic Density	The number of vehicles on a fixed length of roadway at a given instant.
Traffic Volume	The number of vehicles passing a fixed point on a roadway in a given period of time.
Travel Time	The time required by a vehicle to cover a given distance on a roadway.
Videotape	A magnetic tape used to record a television production.
Visibility	A measure of how clear the atmosphere is. Technically, the horizontal distance at which an object can be recognized by the unaided eye.

Work is done when a force is exerted through a distance. Work is the product of the force exerted and the distance moved.

E. Skills, Processes, and Areas of Study Utilized in Traffic Flow

The unique aspect of USMES is the degree to which it provides experience in the process of solving real problems. Many would agree that this aspect of learning is so important as to deserve a regular place in the school program even if it means decreasing to some extent the time spent in other important areas. Fortunately, real problem solving is also an effective way of learning many of the skills, processes, and concepts in a wide range of school subjects.

On the following pages are five charts and an extensive, illustrative list of skills, processes, and areas of study that are utilized in USMES. The charts rate Traffic Flow according to its potential for learning in various categories of each of five subject areas--real problem solving, mathematics, science, social science, and language arts. The rating system is based on the amount that each skill, process, or area of study within the subject areas is used--extensive (1), moderate (2), some (3), little or no use (-). (The USMES Guide contains a chart that rates all USMES units in a similar way.)

The chart for real problem solving presents the many aspects of the problem-solving process that students generally use while working on an USMES challenge. A number of the steps in the process are used many times and in different orders, and many of the steps can be performed concurrently by separate groups of students. Each aspect listed in the chart applies not only to the major problem stated in the unit challenge but also to many of the tasks each small group undertakes while working on a solution to the major problem. Consequently, USMES students gain extensive experience with the problem-solving process.

The charts for mathematics, science, social science, and language arts identify the specific skills, processes, and areas of study that may be learned by students as they respond to a Traffic Flow challenge and become involved with certain activities. Because the students initiate the activities, it is impossible to state unequivocally which activities will take place. It is possible, however, to document activities that have taken place in USMES classes and identify those skills and processes that have been used by the students.

Knowing in advance which skills and processes are likely to be utilized in Traffic Flow and knowing the extent that they will be used, teachers can postpone the teaching of

those skills in the traditional manner until later in the year. If the students have not learned them during their USMES activities by that time, they can study them in the usual way. Further, the charts enable a teacher to integrate USMES more readily with other areas of classroom work. For example, teachers may teach fractions during math period when fractions are also being learned and utilized in the students' USMES activities. Teachers who have used USMES for several successive years have found that students are more motivated to learn basic skills when they have determined a need for them in their USMES activities. During an USMES session the teacher may allow the students to learn the skills entirely on their own or from other students, or the teacher may conduct a skill session as the need for a particular skill arises.

Because different USMES units have differing emphases on the various aspects of problem solving and varying amounts of possible work in the various subject areas, teachers each year might select several possible challenges, based on their students' previous work in USMES, for their class to consider. This choice should provide students with as extensive a range of problems and as wide a variety of skills, processes, and areas of study as possible during their years in school. The charts and lists on the following pages can also help teachers with this type of planning.

Some USMES teachers have used a chart similar to the one given here for real problem solving as a record-keeping tool, noting each child's exposure to the various aspects of the process. Such a chart might be kept current by succeeding teachers and passed on as part of a student's permanent record. Each year some attempt could be made to vary a student's learning not only by introducing different types of challenges but also by altering the specific activities in which each student takes part. For example, children who have done mostly construction work in one unit may be encouraged to take part in the data collection and data analysis in their next unit.

Following the rating charts are the lists of explicit examples of real problem solving and other subject area skills, processes, and areas of study learned and utilized in Traffic Flow. Like the charts, these lists are based on documentation of activities that have taken place in USMES classes. The greater detail of the lists allows teachers to see exactly how the various basic skills, processes, and areas of study listed in the charts may arise in Traffic Flow.

The number of examples in the real problem solving list have been limited because the list itself would be unreasonably long if all the examples were listed for some of the categories. It should also be noted that the example(s) in the first category--*Identifying and Defining Problems*--have been limited to the major problem that is the focus of the unit. During the course of their work, the students will encounter and solve many other, secondary problems, such as the problem of how to display their data or how to draw a scale layout.

Breaking down an interdisciplinary curriculum like USMES into its various subject area components is a difficult and highly inexact procedure. Within USMES the various subject areas overlap significantly, and any subdivision must be to some extent arbitrary. For example, where does measuring as a mathematical skill end and measurement as science and social science process begin? How does one distinguish between the processes of real problem solving, of science, and of social science? Even within one subject area, the problem still remains--what is the difference between graphing as a skill and graphing as an area of study? This problem has been partially solved by judicious choice of examples and extensive cross-referencing.

Because of this overlap of subject areas, there are clearly other outlines that are equally valid. The scheme presented here was developed with much care and thought by members of the USMES staff with help from others knowledgeable in the fields of mathematics, science, social science, and language arts. It represents one method of examining comprehensively the scope of USMES and in no way denies the existence of other methods.

REAL PROBLEM SOLVING	Overall Rating
Identifying and defining problem.	1
Deciding on information and investigations needed.	1
Determining what needs to be done first, setting priorities.	2
Deciding on best ways to obtain information needed.	1
Working cooperatively in groups on tasks.	1
Making decisions as needed.	1
Utilizing and appreciating basic skills and processes.	1
Carrying out data collection procedures--observing, surveying, researching, measuring, classifying, experimenting, constructing.	1
Asking questions, inferring.	1
Distinguishing fact from opinion, relevant from irrelevant data, reliable from unreliable sources.	1

REAL PROBLEM SOLVING	Overall Rating
Evaluating procedures used for data collection and analysis. Detecting flaws in process or errors in data.	1
Organizing and processing data or information.	1
Analyzing and interpreting data or information.	1
Predicting, formulating hypotheses, suggesting possible solutions based on data collected.	1
Evaluating proposed solutions in terms of practicality, social values, efficacy, aesthetic values.	1
Trying out various solutions and evaluating the results, testing hypotheses.	1
Communicating and displaying data or information.	1
Working to implement solution(s) chosen by the class.	1
Making generalizations that might hold true under similar circumstances; applying problem solving process to other real problems.	1

KEY: 1 = extensive use, 2 = moderate use, 3 = some use, - = little or no use

MATHEMATICS	Overall Rating
Basic Skills	
Classifying/Categorizing	3
Counting	1
Computation Using Operations	
Addition/Subtraction	1
Multiplication/Division	1
Fractions/Ratios/Percentages	1
Business and Consumer Mathematics/ Money and Finance	2
Measuring	1
Comparing	3
Estimating/Approximating/Rounding Off	1
Organizing Data	1
Statistical Analysis	1
Opinion Surveys/Sampling Techniques	2
Graphing	1
Spatial Visualization/Geometry	2
Areas of Study	
Numeration Systems	2
Number Systems and Properties	1
Denominate Numbers/Dimensions	1
Scaling	2
Symmetry/Similarity/Congruence	-
Accuracy/Measurement Error/ Extimation/Approximation	1
Statistics/Random Processes/Probability	1
Graphing/Functions	1
Fraction/Ratio	1
Maximum and Minimum Values	3
Equivalence/Inequality/Equations	3
Money/Finance	2
Set Theory	-

SCIENCE	Overall Rating
Processes	
Observing/Describing	1
Classifying	2
Identifying Variables	2
Defining Variables Operationally	2
Manipulating, Controlling Variables/ Experimenting	3
Designing and Constructing Measuring Devices and Equipment	2
Inferring/Predicting/Formulating, Testing Hypotheses/Modeling	1
Measuring/Collecting, Recording Data	1
Organizing, Processing Data	1
Analyzing, Interpreting Data	1
Communicating, Displaying Data	1
Generalizing/Applying Process to New Problems	1
Areas of Study	
Measurement	1
Motion	1
Force	3
Mechanical Work and Energy	3
Solids, Liquids, and Gases	3
Electricity	3
Heat	-
Light	-
Sound	-
Animal and Plant Classification	-
Ecology/Environment	3
Nutrition/Growth	-
Genetics/Heredity/Propagation	-
Animal and Plant Behavior	-
Anatomy/Physiology	-

KEY: 1 = extensive use, 2 = moderate use, 3 = some use, - = little or no use

SOCIAL SCIENCE	Overall Rating
Process	
Observing/Describing/Classifying	2
Identifying Problems, Variables	1
Manipulating, Controlling Variables/ Experimenting	3
Inferring/Predicting/Formulating, Testing Hypotheses	2
Collecting, Recording Data/Measuring	2
Organizing, Processing Data	2
Analyzing, Interpreting Data	2
Communicating, Displaying Data	2
Generalizing/Applying Process to Daily Life	2
Attitudes/Values	
Accepting responsibility for actions and results	1
Developing interest and involvement in human affairs	1
Recognizing the importance of individual and group contributions to society	1
Developing inquisitiveness, self-reliance, and initiative	1
Recognizing the values of cooperation, group work, and division of labor	1
Understanding modes of inquiry used in the sciences, appreciating their power and precision	1
Respecting the views, thoughts, and feelings of others	1
Being open to new ideas and information	1
Learning the importance and influence of values in decision making	1
Areas of Study	
Anthropology	-
Economics	2
Geography/Physical Environment	3
Political Science/Government Systems	1
Recent Local History	3
Social Psychology/Individual and Group Behavior	3
Sociology/Social Systems	2

LANGUAGE ARTS	Overall Rating
Basic Skills	
Reading	
Literal Comprehension: Decoding Words Sentences, Paragraphs	2
Critical Reading: Comprehending Meanings, Interpretation	2
Oral Language	
Speaking	1
Listening	1
Memorizing	3
Written Language	
Spelling	1
Grammar: Punctuation, Syntax, Usage	1
Composition	1
Study Skills	
Outlining/Organizing	1
Using References and Resources	2
Attitudes/Values	
Appreciating the value of expressing ideas through speaking and writing	1
Appreciating the value of written resources	3
Developing an interest in reading and writing	2
Making judgments concerning what is read	2
Appreciating the value of different forms of writing, different forms of communication	1

KEY: 1 = extensive use, 2 = moderate use, 3 = some use, - = little or no use

REAL PROBLEM SOLVING IN TRAFFIC FLOW

Identifying and Defining Problems	• Students identify an area near the school where traffic is frequently backed up in the morning. • See also SOCIAL SCIENCE list: *Identifying Problems, Variables.*
Deciding on Information and Investigations Needed	• During a discussion students decide to collect data on number of cars and amount of time it takes cars to get through the congested area. • After counting cars in the morning, children decide that they need to count them at other times of day. • Students decide to research costs of various changes in the flow of traffic in the problem area.
Determining What Needs to Be Done First, Setting Priorities	• Children decide to collect data on the congested street before trying to propose solutions.
Deciding on Best Ways to Obtain Information Needed	• Students decide that one child will hold the stopwatch while another records times when timing cars and buses passing through congested area. • Students decide that taking photographs is the best way to count the number of cars that are in the congested area at one time. • Children plan to conduct opinion surveys to obtain suggestions for improving the traffic problem. • Children decide to ask traffic officials about traffic laws and methods of collecting traffic data.
Working Cooperatively in Groups on Tasks	• Students form groups to collect data on numbers of cars and times of cars and to take measurements for making a scale map or model of the intersection.
Making Decisions as Needed	• Students decide to work in groups so that more can be accomplished. • Children decide to propose making the street one-way as a solution. • Students decide to make a presentation of their proposed change to local traffic officials.

Utilizing and Appreciating Basic Skills and Processes	• Children use trundle wheels or meter sticks to measure distances for making a scale map or model. • Children make graphs of car counts and times. • Children recognize that making the roadway less congested will help many people besides themselves. • Students write letters to local traffic officials. • See also MATHEMATICS, SCIENCE, SOCIAL SCIENCE, AND LANGUAGE ARTS lists.
Carrying Out Data Collection Procedures--Opinion Surveying, Researching, Measuring, Classifying, Experimenting, Constructing	• Students take photographs and count the number of cars and buses in the photographs. • Students time cars passing through the congested area. • Children measure streets and make a scale map or model of the problem area. • Children conduct opinion survey to find out how others view the traffic problem. • Students investigate the costs of various possible changes. • See also MATHEMATICS list: *Classifying/Categorizing. Measuring.* • See also SCIENCE list: *Observing/Describing; Classifying; Manipulating, Controlling Variables/Experimenting; Designing and Constructing Measuring Devices and Equipment; Measuring/Collecting, Recording Data.* • See also SOCIAL SCIENCE list: *Observing/Describing/Classifying; Manipulating, Controlling Variables/Experimenting; Collecting, Recording Data/Measuring.*
Asking Questions, Inferring	• Students ask whether a particular street is congested and infer from data collected that it is. • Students ask which of several alternative suggestions for rerouting traffic to recommend. They infer that the cheapest and easiest to enforce will be most acceptable to authorities. • See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses/Modeling.* • See also SOCIAL SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses.*
Distinguishing Fact from Opinion, Relevant from Irrelevant Data, Reliable from Unreliable Sources	• Students recognize the qualitative aspects of obtaining data from opinion surveys as distinct from data they gather at the congested area.

Distinguishing Fact from Opinion, Relevant from Irrelevant Data, Reliable from Unreliable Sources (cont.)	• Children recognize that traffic officials are reliable sources for information on traffic laws and that the traffic department can be used to obtain information on costs of various changes.
Evaluating Procedures Used for Data Collection and Analysis, Detecting Flaws in Process or Errors in Data	• Students evaluate the manner in which car and bus times were measured. They agree that they cannot time every car and decide to time only a certain type of car. • Students realize that more than one camera must be used to "cover" the congested area. They decide to use two cameras and synchronize them so that the photos are taken at the same instant. • Children measuring street distances with trundle wheels and meter sticks obtain different results. They discuss the discrepancies and choose the best instrument to use. • Students decide that their opinion surveys are biased towards one favored alternative. They improve the wording to eliminate this problem. • See also MATHEMATICS list: *Estimating/Approximating/ Rounding Off.*
Organizing and Processing Data	• To draw histograms, students order and group measurements of times of cars passing through the congested area. • See also MATHEMATICS list: *Organizing Data.* • See also SCIENCE and SOCIAL SCIENCE list: *Organizing, Processing Data.*
Analyzing and Interpreting Data	• Students find median time for a car to pass through the congested area. • Students find that there are more cars in the congested area in the morning than in the afternoon. • Children find that 90% of the people surveyed feel that the congested area needs some kind of change. • See also MATHEMATICS list: *Comparing; Statistical Analysis; Opinion Surveys/Sampling Techniques; Graphing.* • See also SCIENCE and SOCIAL SCIENCE lists: *Analyzing, Interpreting Data.*
Predicting, Formulating Hypotheses, Suggesting Possible Solutions Based on Data Collected	• After collecting data on traffic flow and conducting an opinion survey, the students decide that parking should be eliminated on the street during congested periods.

Predicting, Formulating Hypotheses, Suggesting Possible Solutions Based on Data Collected (cont.)	• After investigating, students predict that other streets could handle extra traffic if the congested street is made one-way. • See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses/Modeling.* • See also SOCIAL SCIENCE list: *Inferring/Predicting/ Formulating, Testing Hypotheses.*
Evaluating Proposed Solutions in Terms of Practicality, Social Values, Efficacy, Aesthetic Values	• Students evaluate costs of having a policeman or police woman on duty to help direct traffic. • Children determine whether widening the street or making traffic one-way would be a better solution in terms of land use.
Trying Out Various Solutions and Evaluating the Results, Testing Hypotheses	• Students use simulation to model changes in the traffic flow in order to evaluate their proposed solution. • Children collect data after a change has been made to see if the flow of traffic has been improved. • See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses/Modeling.* • See also SOCIAL SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses*
Communicating and Displaying Data or Information	• Students draw bar graphs and histograms to show car counts and times of cars passing through the congested area. • Children make q-q graphs to compare car times passing through the intersection before and after the proposed changes. • Students draw scale layout of congested area. • See also MATHEMATICS list: *Graphing; Scaling.* • See also SCIENCE and SOCIAL SCIENCE lists: *Communicating, Displaying Data.* • See also LANGUAGE ARTS list.
Working to Implement Solution(s) Chosen by the Class	• Students make presentation of proposed changes to traffic authority.
Making Generalizations That Might Hold True Under Similar Circumstances; Applying Problem-Solving Process to Other Real Problems	• Students working on Traffic Flow apply skills acquired to work on Pedestrian Crossings. • Children use graphing skills developed while organizing data on car and bus times for displaying data on other problems.

Making Generalizations That Might Hold True Under Similar Circumstances; Applying Problem-Solving Process to Other Real Problems (cont.)

- See also SCIENCE list: *Generalizing/Applying Process to New Problems.*
- See also SOCIAL SCIENCE list: *Generalizing/Applying Process to Daily Life.*

ACTIVITIES IN TRAFFIC FLOW UTILIZING MATHEMATICS

Basic Skills

Classifying/Categorizing	• Categorizing characteristics (number of cars, types of streets or intersections) where the flow of traffic is impeded. • See also SCIENCE list: *Classifying*. • See also SOCIAL SCIENCE list: *Observing/Describing/ Classifying*.
Counting	• Counting survey data on opinions of parents, students, officials, etc., about a traffic problem. • Counting number of minutes or seconds, number of meters, number of cars while collecting traffic data. • Counting by sets to find scale for graph axes. • Counting votes for determining what solution to recommend.
Computation Using Operations: Addition/Subtraction	• Adding one- or two-digit whole numbers to find total tally of cars or total measurement of street length. • Adding minutes and seconds when timing cars. • Subtracting to find differences between car speeds before and after the speed limit is changed. • Subtracting one- or two-digit whole numbers to find ranges for graph axes or for measurement data. • Subtracting medians to compare sets of data.
Computation Using Operations: Multiplication/Division	• Multiplying whole numbers to find total tally of cars, total measurement of street length. • Using multiplication and division to increase or decrease measurements for scale drawings, scale models. • Multiplying and dividing to convert feet per second to miles per hour. • Dividing to calculate average travel time, car speed, number of cars. • Dividing to calculate percentage of cars traveling a certain speed or less, etc.
Computation Using Operations: Fractions/Ratios/Percentages	• Using mixed numbers in making a scale model. • Changing fractions to higher or lower terms (equivalent fractions) to perform operations such as addition and division.

Computation Using Operations: Fractions/Ratios/Percentages (cont.)	• Using ratios and fractions to convert from feet per second to miles per hour. • Using ratios to increase or decrease measurements for a scale drawing or model of a problem area. • Using fractions in measurement, graphing, graphic comparisons, scale drawings or models. • Calculating percentage of people favoring particular solutions to a traffic problem. • Calculating actual measurements from scale maps of an intersection using ratio of scale map. • Calculating percentage of cars turning right, percentage of cars traveling a certain speed or under, etc.
Computation Using Operations: Business and Consumer Mathematics/ Money and Finance	• Adding, subtracting, multiplying, and dividing dollars and cents to perform cost analysis of various solutions to a traffic problem. • Gaining experience with finance: sources, uses, and limitations of revenues for road design, constructions, etc. • Investigating and comparing costs of widening road, making new roads, synchronizing traffic control equipment, etc.
Measuring	• Converting from yards to feet, inches to feet, centimeters to meters, minutes to seconds, and vice versa. • Using different standard units of measure to measure distances of roadways. • Using different measuring tools to measure lengths, widths of roadways. • Reading stopwatches, meter sticks, tape measures, trundle wheels accurately. • See also SCIENCE list: *Measuring/Collecting, Recording Data*. • See also SOCIAL SCIENCE list: *Collecting, Recording Data/ Measuring*.
Comparing	• Comparing quantitative data on travel times, traffic density, and speed gathered along roadways with information gathered by traffic officials. • Comparing qualitative information on a problem area gathered from various sources, such as people's observations and opinions. • Comparing qualitative data gathered from an opinion survey with quantitative data gathered at the problem area. • Comparing estimated and actual measurements on car speeds, street length.

Comparing (cont.)	• Making graphic comparisons of car travel times at different times of day. • Comparing costs of various alternative solutions. • Comparing speeds of cars along a roadway. • See also SCIENCE list: *Analyzing, Interpreting Data.* • See also SOCIAL SCIENCE list: *Analyzing, Interpreting Data.*
Estimating/Approximating/ Rounding Off	• Estimating error in qualitative judgments on traffic problems when collecting survey data. • Estimating the number of cars that will slow down if the speed limit is changed. • Estimating car travel times before collecting data or costs of different solutions before checking with authorities. • Estimating traffic density by eyeballing. • Determining when a measurement of street distance is likely to be accurate enough for a scale map. • Using approximation when constructing scale models. • Rounding off data while measuring length of streets, travel times, etc. • Rounding off data after measuring length of streets, speeds, etc.
Organizing Data	• Tallying on bar graphs, histograms. • Ordering real numbers on graph axis. • Ordering the steps in the process of collecting data. • Ordering survey results on opinions about a traffic problem. • Ordering number of centimeters, seconds, etc. • Ordering quantitative data on distances, travel times, speeds. • See also SCIENCE list: *Organizing, Processing Data.* • See also SOCIAL SCIENCE list: *Organizing, Processing Data.*
Statistical Analysis	• Finding the median in an ordered set of data on travel times, number of cars, etc. • Taking repeated measurements of street widths and using the median measurement. • Assessing accuracy of estimate of all car times passing through a problem area based on results from a small sample. • Finding quartiles from ordered data or histogram on car travel times.

Statistical Analysis (cont.)	• Determining the interquartile range of travel time data. • See also SCIENCE list: *Analyzing, Interpreting Data.* • See also SOCIAL SCIENCE list: *Analyzing, Interpreting Data.*
Opinion Surveys/Sampling Techniques	• Conducting opinion surveys about traffic problems; defining data collection methods, makeup and size of sample. • Devising methods of obtaining quantitative information about subjective opinions on traffic problems. • Evaluating the way survey was organized, data obtained, size and type of samples. • See also SCIENCE list: *Analyzing, Interpreting Data.* • See also SOCIAL SCIENCE list: *Analyzing, Interpreting Data.*

Graphing	• Using alternative methods of displaying data on car speeds.
	• Making a graph form--dividing axes into parts, deciding on an appropriate scale.
	• Representing data on graphs.
	  • Bar graph--plotting individual car travel times, traffic density at different times of day.
	  • Histogram--plotting the number of cars that pass through in certain times (travel times).
	  • Conversion graph--plotting feet per second vs. miles per hour.
	  • Scatter graph--plotting distances of bus routes vs. times the buses take.
	  • Q-Q graph--plotting car travel times before a change vs. times after a change.
	• Obtaining information from graphs on car travel times, speeds, number of cars.
	• Representing several sets of data on one graph, e.g., speeds of cars at different times of day.
	• See also SCIENCE list: *Communicating, Displaying Data.*
	• See also SOCIAL SCIENCE list: *Communicating, Displaying Data.*

Spatial Visualization/Geometry	• Drawing a map or constructing a model of a congested area. • Designing a new system of roadways. • Constructing and using a circle when making a trundle wheel.

Spatial Visualization/Geometry	• Using standard mensurational formulas such as circumference (of trundle wheel) = π x diameter. • Measuring and constructing a scale model using rulers or meter sticks. • Using spatial arrangements to convey information about a congested area.

Areas of Study

Numeration Systems	• Using metric system in measuring distances. • Using fractions in measuring feet. • Using decimal system in making cost analyses of various solutions.
Number Systems and Properties	• See *Computation Using Operations*.
Denominate Numbers/Dimensions	• See *Measuring*.
Scaling	• Deriving information from scale maps or scale models of a problem area. • Finding an appropriate scale for the scale map or model. • Using a scale to draw and make representations in the scale map or model. • Making a scale map or model of a problem area.
Symmetry/Similarity/Congruence	• See *Spatial Visualization/Geometry*.
Accuracy/Measurement Error/ Estimation/Approximation	• See *Measuring* and *Estimating/Approximating/Rounding Off*.
Statistics/Random Processes/ Probability	• See *Statistical Analysis*.
Graphing/Functions	• See *Graphing*.
Fraction/Ratio	• See *Computation Using Operations: Fractions/Ratios/ Percentages*.

Maximum and Minimum Values	• Finding the traffic solutions that will solve the problem at minimum cost.
Equivalence/Inequality/Equations	• See *Comparing* and *Computation Using Operations*
Money/Finance	• See *Computation Using Operations: Business and Consumer Mathematics/Money and Finance.*

ACTIVITIES IN TRAFFIC FLOW UTILIZING SCIENCE

Process

Observing/Describing	• Observing and describing various traffic problems in the vicinity of the school. • Noting that traffic is greater at certain times of day. • Describing various kinds of traffic systems and how they are suited to different areas. • See also SOCIAL SCIENCE list: *Observing/Describing/ Classifying*.
Classifying	• Classifying streets as congested or uncongested. • Classifying alternative road designs or systems by expense, efficiency, etc. • See also MATHEMATICS list: *Classifying/Categorizing*. • See also SOCIAL SCIENCE list: *Observing/Describing/ Classifying*.
Identifying Variables	• Identifying travel times, car speeds, number of vehicles, width of roadway, as things to measure for determining safety or congestion of a roadway. • Identifying number of cars, speeds of cars, travel times, system of roadways as factors to change to make the roadway safer. • Identifying time of day and weather as factors to be held constant. • See also SOCIAL SCIENCE list: *Identifying Problems, Variables*.
Defining Variables Operationally	• Defining travel time as the time a car takes to go from one point to another. • Defining number of vehicles as number of cars or buses in a certain distance of roadway at a certain time. • Defining specific time or distance to be used in collecting data on speed.
Manipulating, Controlling Variables/Experimenting	• Measuring travel times, speeds of cars, and number of cars at same times of the day and in the same weather conditions to compare different problem locations. • Measuring car speeds before and after warning signs are put up.

Manipulating, Controlling Variables/Experimenting (cont.)	• See also SOCIAL SCIENCE list: *Manipulating, Controlling Variables/Experimenting.*
Designing and Constructing Measuring Devices and Equipment	• Constructing trundle wheels for measuring street distances.
Inferring/Predicting/Formulating, Testing Hypotheses/Modeling	• Inferring from the data collected that a street is congested. • Predicting that making a street one-way will alleviate the congestion. • Designing simulations to try out various possible solutions. • See also SOCIAL SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses.*
Measuring/Collecting, Recording Data	• Using a stopwatch to measure travel times and recording them. • Taking photographs to determine density of cars. • Taking distance and time measurements to determine speed. • Measuring distances of streets in order to make a scale map or model of the area. • Collecting and recording data obtained from simulations. • See also MATHEMATICS list: *Measuring.* • See also SOCIAL SCIENCE list: *Collecting, Recording Data/Measuring.*
Organizing, Processing Data.	• Ordering travel time, car speed, and density data from smallest to largest. • Tabulating measurements of the problem area before making a scale map or model. • Ordering data obtained from simulations of alternative traffic flow patterns. • See also MATHEMATICS list: *Measuring, Organizing Data.* • See also SOCIAL SCIENCE list: *Organizing, Processing Data.*
Analyzing, Interpreting Data	• Calculating the average or median travel time or speed. • Determining that an area is congested from analysis of number of cars and car travel time. • Determining that a particular solution is best from results of simulations.

Analyzing, Interpreting Data (cont.)	• See also MATHEMATICS list: *Comparing; Statistical Analysis; Graphing; Opinion Surveys/Sampling Techniques.* • See also SOCIAL SCIENCE list: *Analyzing, Interpreting Data.*
Communicating, Displaying Data	• Showing data on various types of graphs. • Showing problems and solutions on a scale map or model of the intersection. • See also MATHEMATICS list: *Graphing.* • See also SOCIAL SCIENCE list: *Communicating, Displaying Data.* • See also LANGUAGE ARTS list.
Generalizing/Applying Process to New Problems	• Using knowledge acquired from working on a traffic problem to help solve other problems involving traffic or pedestrians, as in Pedestrian Crossings unit. • See also SOCIAL SCIENCE list: *Generalizing/Applying Process to Daily Life.*
Areas of Study	
Measurement	• Using stopwatches to measure arrival times for cars, speed of cars, and car travel times. • Measuring distances with trundle wheels, meter sticks, yardsticks, and tape measures. • Using photographs to determine traffic density. • See also MATHEMATICS list: *Measuring.*
Motion	
Speed/Velocity	• Observing and calculating the speeds of cars.
Circular Motion	• Noting that the circular motion of the car wheels is changed to the forward motion of the automobile; noting that forward motion of trundle wheel is changed to circular motion.
Acceleration	• Observing acceleration when cars gradually gain speed as they start from a stop. • See also *Force.*

Force	• Observing that force must be used to push a trundle wheel or use a hand saw.
Centripetal Force	• Observing that toy cars fall off model cloverleaf ramps if they are moving too fast or if the curvature of the ramp is too great; noting that the force required to keep an object moving along a curved path increases as the velocity increases, increases as mass increases, and increases as the radius of the curve decreases.
Momentum/Inertia	• Noting that cars take longer to stop if their initial speed is greater because of their greater momentum. • Observing that objects at rest do not move until a force acts upon them. • Noting that cars stay in motion at a constant speed unless an outside force acts upon them.
Friction	• Observing that the road surface becomes heated when cars stop quickly because friction between the two surfaces generates heat. • Observing that cars skid more easily on wet spots or icy patches because smooth surfaces generate less friction than rough ones.
Mechanical Work and Energy	• Observing that pushing trundle wheels or hand saws or hammering nails requires energy. • Observing that saber saws require less human work to use than hand saws because they transform electrical energy into mechanical energy. • See also *Motion* and *Force*.
Solids, Liquids, and Gases	
Properties of Matter	• Comparing the properties of lumber and Tri-Wall before constructing scale models of trundle wheels.

ACTIVITIES IN TRAFFIC FLOW UTILIZING SOCIAL SCIENCE

Process

Observing/Describing/Classifying	• Organizing and classifying sets of ideas or information. • Observing and describing problems of children riding buses that are held up by traffic congestion. • See also MATHEMATICS list: *Classifying/Categorizing.* • See also SCIENCE list: *Observing/Describing/Classifying.*
Identifying Problems, Variables	• Identifying problems of children who are late for school because of traffic jams. • Identifying factors that affect drivers (weather, frustration due to being "stuck" in traffic, etc.). • Identifying variables that affect the results on an opinion survey, e.g., time of day, age of people, habits of people. • See also SCIENCE list: *Identifying Variables.*
Manipulating, Controlling Variables/ Experimenting	• Conducting an opinion survey of different ages of people, at different times of day or under different conditions to see whether there is a change. • See also SCIENCE list: *Manipulating, Controlling Variables/Experimenting.*
Inferring/Predicting/Formulating, Testing Hypotheses	• Inferring that the results of an opinion survey of a sample of people reflect the opinions of many people. • Inferring that a particular street is most congested, based on results from an opinion survey. • Inferring that a particular solution to a traffic problem is preferred, based on preference surveys of drivers, local officials, or residents. • See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses.*
Collecting, Recording Data/ Measuring	• Collecting data in opinion surveys. • Using a voting procedure to determine who will be in each group (if there is a conflict). • See also MATHEMATICS list: *Counting; Measuring.* • See also SCIENCE list: *Measuring/Collecting, Recording Data.*

Organizing, Processing Data	• Tallying votes to determine which solution to recommend. • Tallying and ordering results of questionnaire data on traffic problems or on preferences for a solution. • See also MATHEMATICS list: *Measuring*. • See also SCIENCE list: *Measuring/Collecting, Recording Data*.
Analyzing, Interpreting Data	• Comparing qualitative information gathered from interviews of various groups of people. • Evaluating way in which survey was administered, size and makeup of sample. • Comparing data obtained from different groups of people or from samples of different sizes. • Assessing accuracy of the results of the opinion surveys. • See also MATHEMATICS list: *Comparing; Statistical Analysis; Graphing; Opinion Surveys/Sampling Techniques*. • See also SCIENCE list: *Analyzing, Interpreting Data*.
Communicating, Displaying Data	• Representing survey data on traffic problems or solutions on graphs or charts. • See also MATHEMATICS list: *Graphing*. • See also SCIENCE list: *Communicating, Displaying Data*. • See also LANGUAGE ARTS list.
Generalizing/Applying Process to Daily Life	• Using knowledge acquired from taking opinion surveys of drivers to help solve other problems where attitudes are important. • Using knowledge acquired while working on a traffic problem to help solve other urban problems. • See also SCIENCE list: *Generalizing/Applying Process to New Problems*.
Attitudes/Values	
Accepting Responsibility for Actions and Results	• Making sure that various tasks, such as data collecting, making scale models, trundle wheels, etc., are done. • Scheduling and giving presentations to persons in authority (principal, traffic department officials). • Making sure that data collection activities are carried out safely and efficiently.
Developing Interest and Involvement in Human Affairs	• Attempting to have dangerous or congested roadways improved.

Recognizing the Importance of Individual and Group Contributions to Society	• Recognizing that their improvement of a roadway helps others. • Assessing the effects of group action on local government regulations.
Developing Inquisitiveness, Self-Reliance, and Initiative	• Conducting group sessions. • Finding solutions to problems encountered in addition to the main problem of the challenge. • Using the telephone to find information, to get in touch with officials, etc. • Choosing and developing the best way of presenting to traffic authorities a plan for improving a roadway.
Recognizing the Values of Cooperation, Group Work, and Division of Labor	• Finding that work on a traffic problem progresses more rapidly and smoothly when they work in groups. • Eliminating needless overlap in work. • Finding that work is fun when people cooperate.
Understanding Modes of Inquiry Used in the Sciences, Appreciating their Power and Precision	• Using scientific modes of inquiry to investigate and solve a problem with a dangerous or congested area. • Convincing others through use of supporting data, graphs, and maps that their improvements to a roadway are needed and desirable. • Seeing that various traffic improvements can be simulated by using a scale model. • See MATHEMATICS and SCIENCE lists.
Respecting the Views, Thoughts, and Feelings of Others	• Considering all suggestions and assessing their merit. • Considering the opinions of others when proposing a change for a traffic problem. • Recognizing and respecting differences in values according to age, experience, occupation, income, interests, culture, race, religion, ethnic background.
Being Open to New Ideas and Information	• Asking other members of the class for ideas, suggestions. • Considering other ways of doing various tasks. • Conducting library research on traffic laws, economics of road design, etc. • Asking other people for opinions, ideas, and information by conducting interviews or surveys.

Learning the Importance and Influence of Values in Decision Making	• Realizing that cost effectiveness alone is not sufficient in considering a solution to a traffic problem; effects on people, land, and communities must also be considered. • Realizing that motorists and pedestrians have different values that affect their preference for regulations and road design and that both must be considered in any solution.
Areas of Study	
Economics	• Investigating and analyzing costs of various improvements to a traffic problem. • Gaining experience with finance: sources, uses, and limitations of revenues for road construction, traffic controls, etc.
Geography/Physical Environment	• Investigating differences in traffic problems due to differences in topography of a region (e.g., steep hills). • Making and using maps of streets near the school.
Political Science/Government Systems	• Investigating systems of administration and control; deciphering role of governing body over the body that is governed. • Investigating traffic rules and regulations. • Working with school and traffic authorities to discuss improvements for roadways. • Finding the most effective way to influence decision making about a traffic problem.
Recent Local History	• Investigating previous attempts to improve a dangerous or congested traffic situation. • Investigating frequency and causes of previous traffic accidents.
Social Psychology/Individual and Group Behavior	• Developing a gimmick for advertising the need for driver caution and safe practices. • Finding the most effective way to approach traffic authorities about a problem. • Recognizing need for leadership within small and large groups; recognizing differing capacities of individuals for various roles within groups.

Social Phychology/Individual and Group Behavior (cont.)	• Analyzing the effects of a small group making decisions for a larger group.
Sociology/Social Systems	• Investigating problems and making changes that affect not only themselves, but other students and people in the community. • Devising a system of working cooperatively in small and large groups. • Working within established social systems--the school or community--to promote changes in a problem area. • Recognizing that there are many different social groups and that one person belongs to more than one social group.

ACTIVITIES IN TRAFFIC FLOW UTILIZING LANGUAGE ARTS

Basic Skills

Reading: Literal Comprehension--Decoding Words, Sentences, and Paragraphs	• Decoding words, sentences, and paragraphs while reading information on traffic regulations, traffic controls, etc.
Reading: Critical Reading--Comprehending Meanings, Interpretation	• Obtaining factual information about traffic regulations, controls, etc. • Understanding what is read about traffic regulations, controls, costs, etc. • Interpreting what is read, such as rules, regulations, information on costs.
Oral Language: Speaking	• Offering ideas, suggestions, and criticisms during discussions in small group work and class discussions on problems and proposed solutions. • Reporting to class on data-collecting, graphing, map-drawing activities of small groups. • Responding to criticisms of activities. • Preparing, practicing, and giving effective oral presentations as part of the solution to the challenge. • Preparing, practicing, and giving skits, slide/tape shows, public address announcements, etc., promoting driver safety. • Using the telephone properly and effectively to obtain information about traffic regulations, traffic controls, costs of various solutions, etc. • Conducting opinion surveys on traffic problems. • Using rules of grammar in speaking.
Oral Language: Listening	• Conducting interviews of drivers, merchants, authorities. • Following spoken directions.
Oral Language: Memorizing	• Memorizing portions of oral presentations on a traffic problem and proposed solutions.
Written Language: Spelling	• Using correct spelling in writing reports, letters to authorities proposing solutions to a traffic problem.

Written Language: Grammar--Punctuation, Syntax, Usage	• Writing to communicate effectively: • preparing written reports and letters using notes, data, graphs, etc., communicating need for proposed changes at a congested or dangerous location • writing slogans, skits, videotape skits, posters, etc., promoting driver safety • writing opinion surveys for deivers or other people; devising questions to elicit desired information; judging whether a question is relevant and whether its meaning is clear.
Study Skills: Outlining/Organizing	• Taking notes when consulting authorities or books about road design, traffic rules, costs, etc. • Developing opinion survey for drivers or others; ordering questions around central themes, such as traffic problems or possible solutions. • Planning presentations, data collection schemes, etc. • Planning and preparing drafts of letters, reports for critical review by the class before final copy is written. • Organizing ideas, facts, data for inclusion in letters, reports, presentations, etc.
Study Skills: Use of References and Resources	• Using the library to research information on road design, traffic regulations, controls, etc. • Inviting a traffic authority to speak to the class and answer questions for them. • Using indexes and tables of contents of books to locate desired information. • Using "How To" Cards for information on graphing, using a stopwatch, etc.
Attitudes/Values	
Appreciating the Value of Expressing Ideas Through Speaking and Writing	• Finding that traffic officials may be persuaded to change a road design when presented with definite, documented reasons for doing so.
Appreciating the Value of Written Resources	• Finding that certain desired information can be found in books on road design, regulations, traffic, etc.

Developing an Interest in Reading and Writing	• Willingly looking up information on road design, costs, regulations, etc. • Looking up more detailed information on road design, costs, regulations, etc. • Showing desire to work on drafting letters, reports, on scripting skits, videotapes, etc.
Making Judgments Concerning What is Read	• Deciding whether what is read is applicable to the particular problem. • Deciding how reliable the information obtained from reading is. • Deciding whether the written material is appropriate, whether it says what it is supposed to say, whether it may need improvement.
Appreciating the Value of Different Forms of Writing, Different Forms of Communication	• Finding that how information can be best conveyed is determined in part by the audience to whom it is directed. • Finding that certain data or information can be best conveyed by writing it down, preparing graphs or charts, etc. • Finding that certain data or information should be written down so that it can be referred to at a later time. • Finding that spoken instructions are sometimes better than written instructions, and vice versa.